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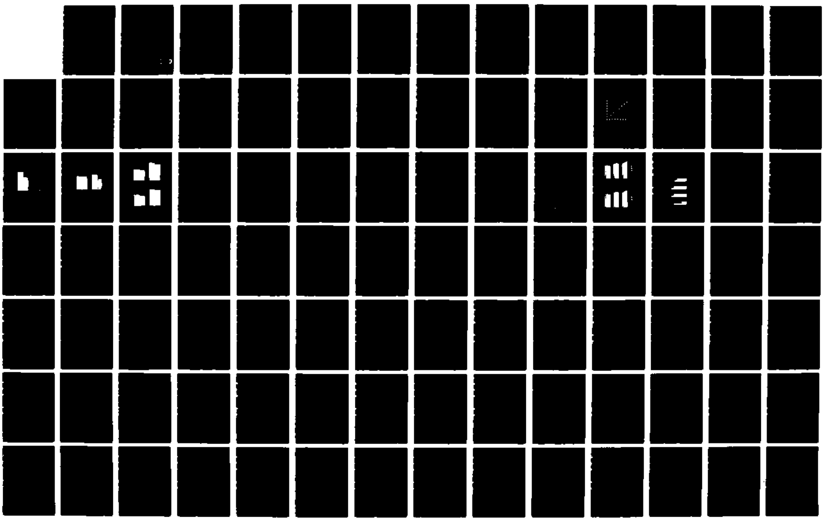

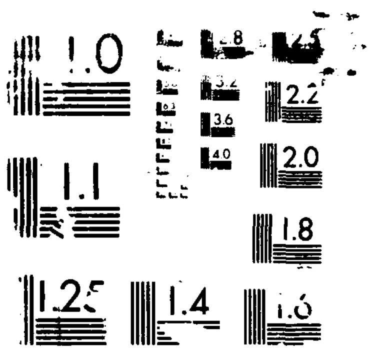

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A psychologically-oriented conceptual framework of distributed tactical decision making (DTDM), applicable to future Naval Battle Groups/Forces operating within a reconfigurable command and control system in a multi-threat environment, is subjected to critical analysis. Empirical results point to the need for more systematically addressing the issues of performance measurement and the means to facilitate proper distribution of resources to enhance overall group performance.

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ABSTRACT

A proposed psychologically-oriented conceptual framework of distributed tactical decision making (DTDM) is presented which is applicable to future Naval Battle Groups/Forces operating with a flexible and reconfigurable command and control system in a multi-threat environment.

The framework distinguishes between input factors (e.g., individual, group, process control and task level), characteristics of group's interaction process, and various outcome variables. The interaction process is assumed to influence the input factors in determining performance outcomes. Based on this framework, two versions of a computer-simulated game representing a "space war" battle context were devised and two experiments were conducted to test some of the underlying assumptions. Cooperative decision making was investigated in two experiments using a social dilemmas paradigm. Important intervening variables investigated include incentive structure, cognitive model similarity, robustness of the centralized network, perceived cooperation and performance, and information availability.

The incentive structure was shown to have an effect on the number of cooperative acts. Poor performance of the subordinates tended to increase the likelihood of battle group commanders taking over decision-making authority from subordinates, and to affect the evaluation of the subordinates' and overall mission success. The degree of cooperation was found to be dependent jointly on the resources received and the performance (both individual and group) factors.

Results point to the need for more systematically addressing the issues of performance measurement and the means to facilitate proper distribution of resources to enhance overall group performance. It was emphasized that in order to improve the operations of a theoretically optimum DTDM system, the important factors of group interaction and cognitive model similarity/consistency of group members should be taken into account in its design. Research should further explore these variables in a simulated game environment.

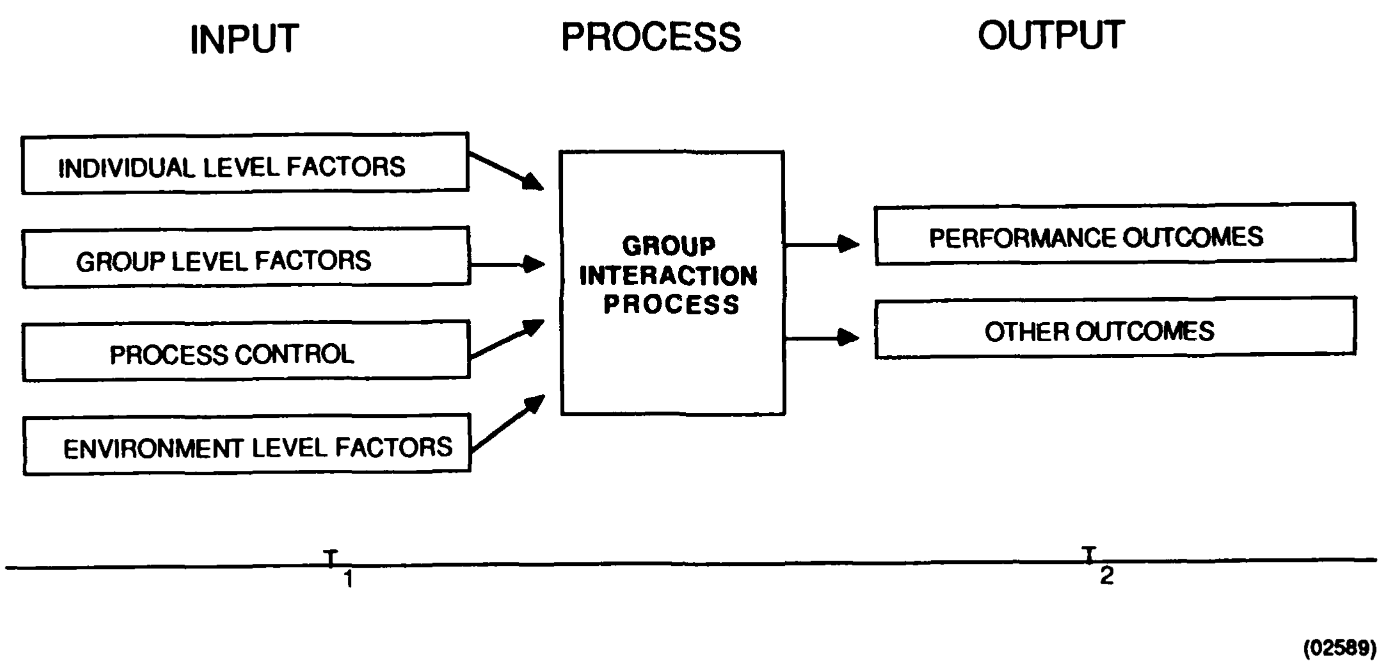
INTRODUCTION

Many of today's complex military systems require effective decision making within distributed tactical environments. For example, future Naval Battle Groups/Forces will be operating with a flexible and reconfigurable command and control system in a multithreat environment. In this operational environment, one person (the Battle Group Commander) is responsible for global decision making. Other commanders are responsible for localized areas of decision making (e.g., anti-aircraft warfare) but must be capable of either assuming more global decision-making responsibilities if need be, or switching local areas of responsibility. Each commander has control of resources that can be used to perform multiple functions in the multithreat environment, and each is expected to reallocate assigned resources according to some strategy of cooperation. This report summarizes a postulated psychologically-oriented framework for investigating distributed tactical decision making (DTDM). From this framework empirical studies may be derived, and the results of the studies may be applied to real-world situations. The report also provides, in capsule form, a review of the first two experiments conducted as part of this project (the first of which was fully presented in Adelman, Zirk, Lehner, Moffett and Hall, 1986). Finally, a detailed summary of the third and fourth experiments is presented. The summary explores further the variables postulated within the conceptual framework, and attempts to integrate these findings with the results of the first two experiments.

CONCEPTUAL FRAMEWORK

Figure 1 presents a general framework, adapted from the work of Hackman and Morris (1975), for the analysis of the relationships among input, interaction process, and output variables in small decision-making groups, irrespective of whether or not group members are spatially separated (i.e., distributed). The input variables represent the different individual, group, process control, and environmental level factors that provide a context for decision making. In distributed tactical decision making environment (DTDM), factors on the individual level represent those cognitive characteristics of group members that directly affect their perception of the dynamic tactical problem context and, in turn, their interactions with each other and their subordinates. Examples of individual-level factors affecting group members' cognitive models include background knowledge, cognitive style, status, and skills. Group-level factors directly affect the cooperativeness of members operating within a DTDM environment. Examples of group-level factors include the group's reward structure, norms, size, history, and composition. Although there are many different types of process control factors, those particularly relevant to the DTDM environment are the various characteristics of the C^2 network that members must use to interact with each other. The extent to which the network permits an effective division of labor among group members and allocation of resources is particularly important. Examples of process control factors affecting the command/communication environment include: (1) the degree of centrality, i.e., the extent to which decision- making control is centralized about the global commander or decentralized to local commanders, (2) the network's flexibility for reconfiguration, (3) the network's display capabilities, and (4) its data base characteristics. Finally, environmental input factors define different representative problem contexts for DTDM that vary in problem complexity. Examples of environmental factors relevant to DTDM include mission objectives, threat characteristics, and the amount and distribution of resources.

The interaction process refers to the observable behavior that occurs during the time the group is working together, i.e., T1 to T2 in Figure 1. The basic assumption of the conceptual framework postulated at the outset of this research effort was that input variables affect the group's interaction process and that, in turn, the process affects performance. Research by Hackman and Morris (1975) and by Janis and Mann (1977) has shown that the group's process norms (input) affect the extent to which divergent performance strategies for addressing a task are discussed by the group; that is, input variables affect the interaction process. Although there are numerous process variables that can be considered in a DTDM environment, the research reported herein focuses on group cooperation in terms of the amount of cooperation, whether it is voluntary, requested, or



GENERAL CONCEPTUAL FRAMEWORK RELATION INPUT, PROCESS, AND OUTPUT VARIABLES OPERATING IN SMALL DECISION MAKING GROUPS
FIGURE 1

forced, and the timeliness with which it is provided by group members.

The output variables in the conceptual framework presented in Figure 1 represent measures of effectiveness. These include objective performance outcomes that measure both group and individual performance, as well as more subjective outcomes such as the perceived quality of the individual and group decision-making process and performance, member morale, and the level of interpersonal understanding.

An important assumption underlying the above conceptual framework is that the interaction process mediates the influence of input factors on performance outcomes. This perspective is particularly important in a DTDM environment, where it is tempting to assume that advanced communication and computation of ever increasing capabilities will ensure successful group performance simply by improving the interaction process. The research summarized by Steiner (1972) and performed by Stumpf, Freedman, and Zand (1979) indicates that the capability for a good interaction process will not necessarily ensure high levels of group performance, for the potential productivity of the group may remain low due to various individual and group input factors. It follows then that generating a strictly mathematical and information theoretic model of C^2, such as that of Tenney and Sendell (1981a, 1981b) or Levis (1984), for the sake of an "optimal" design of C^2 systems is necessary, but not sufficient to guarantee high levels of performance in a DTDM environment. A wide range of input factors would still exist that could lead decision makers to make suboptimal use of a theoretically optimal C^2 system. Consequently, it is important to develop and validate a psychological theory of DTDM that would predict the contexts in which suboptimal use of a theoretically optimal system occurs. From the outset, this has been the overall goal of this research effort. This final report documents our efforts towards that end.

EXPERIMENTS

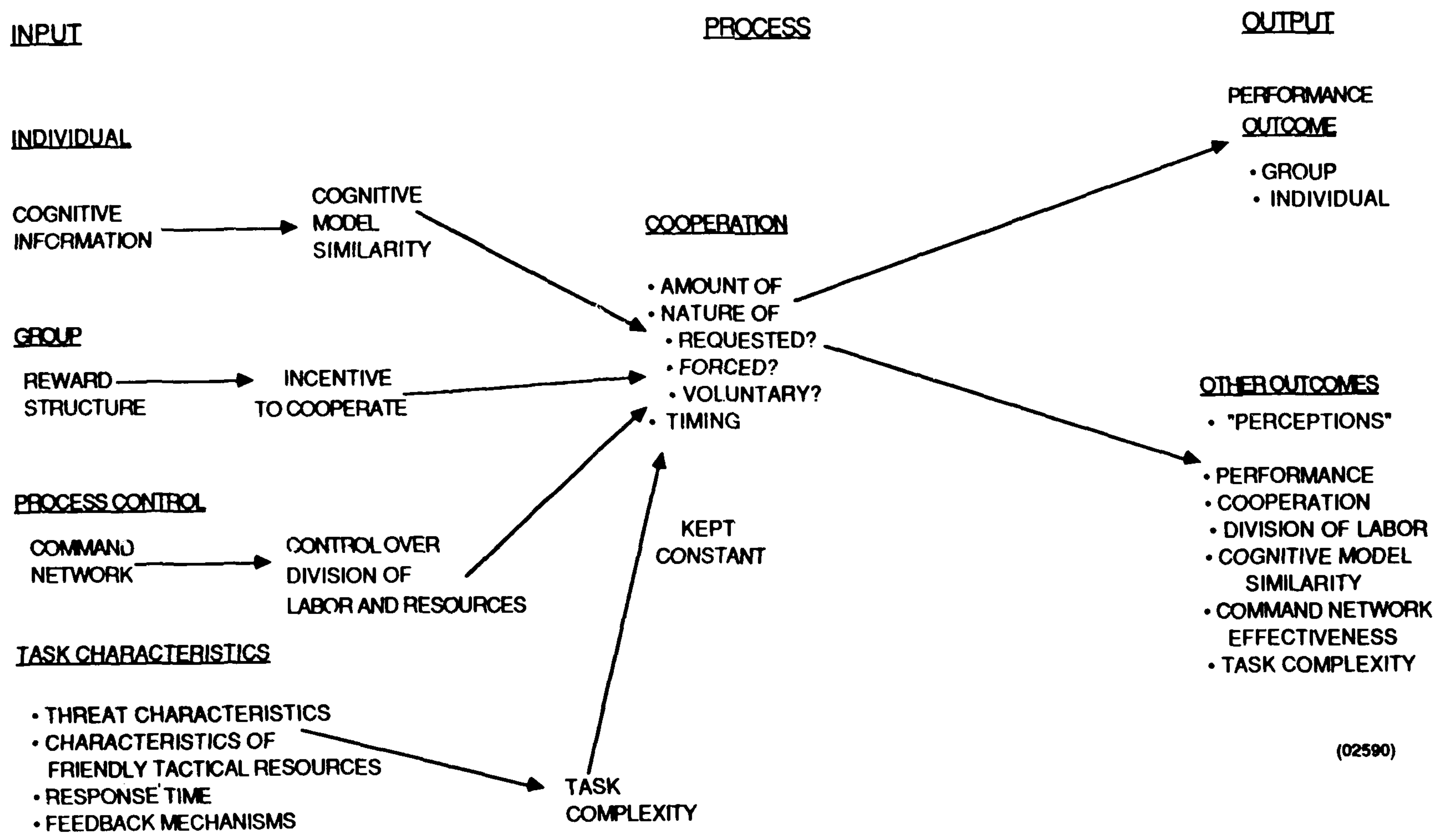
The following section details the experiments conducted in support of this research program. As related above, the first experiment will be presented in summary form, having been presented in detail elsewhere.

EXPERIMENT 1

At the outset of the first experiment, it was hypothesized that three intervening variables would be important mediators of group performance in DTDM environments. The first is that the more the communication network facilitates an effective division of labor, the greater is the probability that the best resources/skills will be put against appropriate aspects of the problem(s). The second is that the more the interacting group members have incentives for cooperative decision-making behavior, the better the resulting group performance. (Without incentives for cooperative decision making, it was hypothesized that group members will not effectively reallocate resources, even though they may have a communication network that permits the effective division of labor.) The third hypothesized mediator of group performance is that group members who consistently apply common cognitive models will display better group decision-making behavior. (Without the consistent application of common cognitive models, it was predicted that the group's performance will suffer even when the group has the communication capabilities for implementing effective DTDM and incentives for supporting it.)

As mediators, the proposed intervening variable constructs represent a proposed theoretical innovation believed to be required to effectively (1) utilize Hackman and Morris' (1975) conceptual framework of small group decision making in the study of DTDM, and (2) address many of the cognitive psychology and group dynamics issues inherent in DTDM. Moreover, as suggested by Adelman, Zirk, and Lehner (1985), there are empirical results from the communication network, cognitive conflict, and game theory research paradigms that support the importance of the proposed intervening variables. The initial experiment was conducted to determine whether input variables designed to manipulate the proposed intervening variables would significantly affect group cooperation (i.e.,, process variables) and, in turn, performance in a DTDM environment. This experiment is briefly discussed below.

Figure 2 depicts the experiment within the context of the input-process-output conceptual framework described above. Briefly considering the input variables first, the cognitive information given to individual group members was manipulated to create either cognitive model similarity or



PICTORIAL REPRSENTATION OF INITIAL EXPERIMENT
FIGURE 2

dissimilarity. The group's reward structure was manipulated to vary group members' incentives for cooperation. The command network was either centralized or decentralized, thereby affecting the group leader's ability to control the division of labor and resources. Task complexity was held constant in the experiment.

On the basis of the postulated conceptual framework, it was hypothesized that the input variable manipulations would significantly affect the group's process, in terms of the amount, nature and timing of cooperative behavior and, in turn, the group's output in terms of both objective and subjective performance measures. Specifically, it was hypothesized that cognitive model similarity, group-oriented incentives, and process control via the centralized command network would each result in more effective cooperation and, consequently, better objective group performance and more positive subjective impressions of the group than their counterparts.

The behavioral analysis in this experiment provided support for only one structure of the conceptual framework's input-process-output linkage. Specifically, behavioral analysis supported only the reward structure manipulation designed to influence the "incentive to cooperate" intervening variable. Neither the cognitive information manipulation of cognitive model similarity/dissimilarity nor the command network manipulation of process control had any significant behavioral effects on the DTDM groups. There were no significant command network effects in the behavioral analysis. There were, however, significant effects in both the informational and attitudinal analyses. Informational analysis indicated that information processing efficiency was significantly higher for the centralized rather than decentralized command network. This finding is consistent with process control predictions. In contrast, when command network had a significant effect in the attitudinal analysis, it was always opposite to that predicted by a "process control" mediating variable, for the decentralized command network was always perceived as superior to the centralized network. The attitudinal analysis provided insights into the effect of the different manipulations on the participants' perceptions. Perceived cooperation was the only process variable for which both (1) all participants agreed and (2) the results were consistent with the informational and behavioral analyses.

The findings of the initial experiment represented a first step in the development and refinement of the conceptual framework postulated at the outset of this project. It is important to be mindful of the new ground being broken by the framework offered by the PGSC team. This form of a psychologically based framework represents an important adjunct to mathematical/information theories of C^2, such as might be provided by Tenney and Sandell (1981a, 1981b) and Levis and his associates, cf. Levis (1984) and Levis and Boettcher (1983). Recall that the work of the latter

is oriented toward defining the optimal design of C^2 organizations on the basis of "...data flow formations used to model in a precise manner the various types of interactions between decision makers as well as interactions between humans and the command, control and communication system that supports the organization" (Levis, [13, p. 151]). Although such work may be necessary for the optimal design of C^2 organizations, it has been our consistent contention throughout the life of this project that a focus on data flow formations alone is not sufficient to guarantee high levels of performance in a DTDM environment. One must also focus on individuals and their behavior. There would also still exist a wide range of psychological factors, including perceptions, that would lead to significantly less than optimal performance in a theoretically optimal C^2 system. Recognizing this, the focus of the PGSC DTDM effort centered on identifying the conditions under which cooperative decision making is maintained or breaks down. The ultimate goal of this research effort has been to develop a psychological theory of DTDM that would predict the contexts in which suboptimal use of a theoretically optimal system occurs, and to identify organizational structures that robustly promote high- quality decision-making performance.

INTERIM DISCUSSION

After the completion of the first experiment, the PGSC team began to design an experiment to test the psychological and organizational robustness of DTDM systems. During that time, a pilot study was conducted to further explore the issue of perceived cooperation in relation to resource use. This pilot study is discussed below.

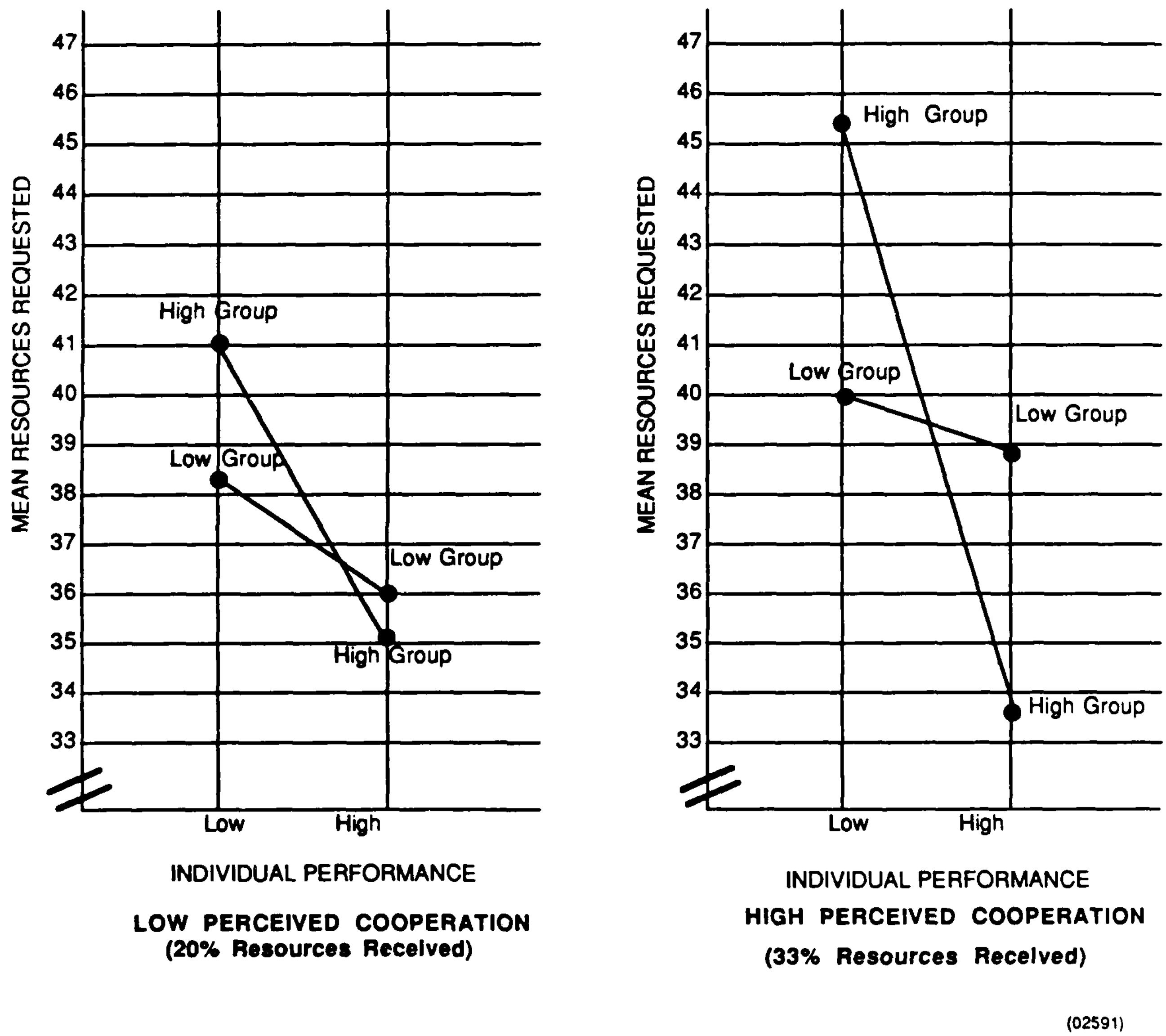
EXPERIMENT 2

Briefly, this experiment required subjects to study a set of battlefield scenarios in which a group of three sector commanders were required to defend a 90-degree sector in space. Each commander was responsible for one 30-degree area and enemy attack was assumed to be equal across all three sectors. Resources were allocated based on the requests made by each sector. If each commander requested one-third of the available resources, each would receive one-third. If, however, any sector requested more than one-third, the additional ships would be subtracted from the remaining sectors' shares. Thus, when a subject received one-third of the available ships, the other members of the group would be perceived as cooperative. When a subject received less than a one-third share, at least one member of the group would be perceived as noncooperative.

On each trial, the subject was given a brief description of the last wave of attack. The description included the three independent variables of interest: (1) Individual performance--identified as either a 40% (low) or 80% (high) successful hit rate; (2) Group performance--identified as either a 40% (low) or 80% (high) hit rate; and (3) Perceived cooperation--identified as the receipt of either 33% of all available ships (cooperation) or 20% of all available ships (non-cooperation). Scenarios were constructed such that all possible combinations of the independent variables were represented across eight scenarios which were administered to subjects in random sequence. For each scenario, subjects chose to request either one-third (cooperative choice) or one-half (noncooperative choice) of available ships to meet the next enemy attack. Subjects were also asked to write a brief rationale for their choice.

At the outset of this pilot study two alternative hypotheses were proposed. It was expected that either individual performance or perceived cooperation would emerge as a main effect. We expected that subjects would either cooperate primarily when their performance was high or subjects would attend to cooperation within the group and behave cooperatively primarily when others had behaved cooperatively.

A 2x2x2 analysis of variance (ANOVA) was conducted and yielded a significant three-way interaction effect ($F=4.59$, $df=1.24$, $p<0.05$) and a significant two-way disordinal interaction ($F=8.91$, $df=1.24$, $p<0.01$). See Figure 3. The results indicated that under the condition of perceived cooperation (where resources were equally shared), subjects tended to cooperate when their individual performance was equal to or greater than group performance. While the pattern of cooperation was similar under the perceived non-cooperation condition, it was more constricted and not significant. Thus, subjects used information on the relationship of individual to group



MEAN PERCENTAGE OF RESOURCES REQUESTED
FIGURE 3

performance and also considered resources received to arrive at a decision. When examining the situation in which individual performance was less successful than group performance, we found that subjects were more cooperative when they had received less than their fair share of resources--a counterintuitive result.

Review of the written rationales yielded clarification of this result. Although subjects were instructed (orally and in writing) to interpret the resources received in each scenario as an indication of how cooperative other sectors had been, the subjects did not use the information in that manner. Across all scenarios, no subject referred to perceived cooperation as a factor in their decision making. When subjects did refer to the resources received, they used the information to evaluate the relative effectiveness of their sector (e.g., "On the last attack I had a 40% hit rate with only 20% of the available ships. That means my hit rate is pretty good given what I had to work with.") Thus, in some instances subjects related performance and resources received to arrive at a simplified concept of "return on investment." This was an unexpected finding but a potentially valuable insight into the decision-making process. Bruner (1986) has encountered similar phenomena in the domain of cognitive psychology whereby subjects construct categories not originally anticipated by the experimenter's paradigm. His recommendation, which we support, is that these reflect the psychological characteristics of the subject and deserve further study.

As an exploratory step, we calculated two additional variables for each scenario. These were: (1) individual return on investment (IROI=individual performance/individual resources received) and (2) group return on investment (GROI=group performance/average amount of resources received by other sectors). Reinterpreting the independent variables in this manner enabled us to compare individual and group return on investment for each scenario. There was only one scenario in which the individual's ROI was less than that of the group. This scenario was also the one in which subjects made the most noncooperative choices. This is consistent with an interpretation that subjects in a group compare their return on investment to that of the group in an effort to maintain equity between the individual and the group as a whole. While this finding is in keeping with literature on equity theory (Greenberg & Cohen, 1982), we emphasize that this was only an ex post facto exploration of the data and is not presented as a firm finding.

INTERIM DISCUSSION

During and following the conduct and analysis of experiment two, the PGSC team proceeded with the discussion and design of an experiment to test the psychological and organizational robustness of a distributed decision- making network. Specifically, the PGSC team was especially concerned

with identifying contexts in which a distributed decision-making network would break down or be maintained. Following the lead of the results of experiment one, the third experiment paid particular attention to issues concerning the preferences for centralized/decentralized networks. The following is a detailed account of the methods, procedures, results, and analysis of this experiment.

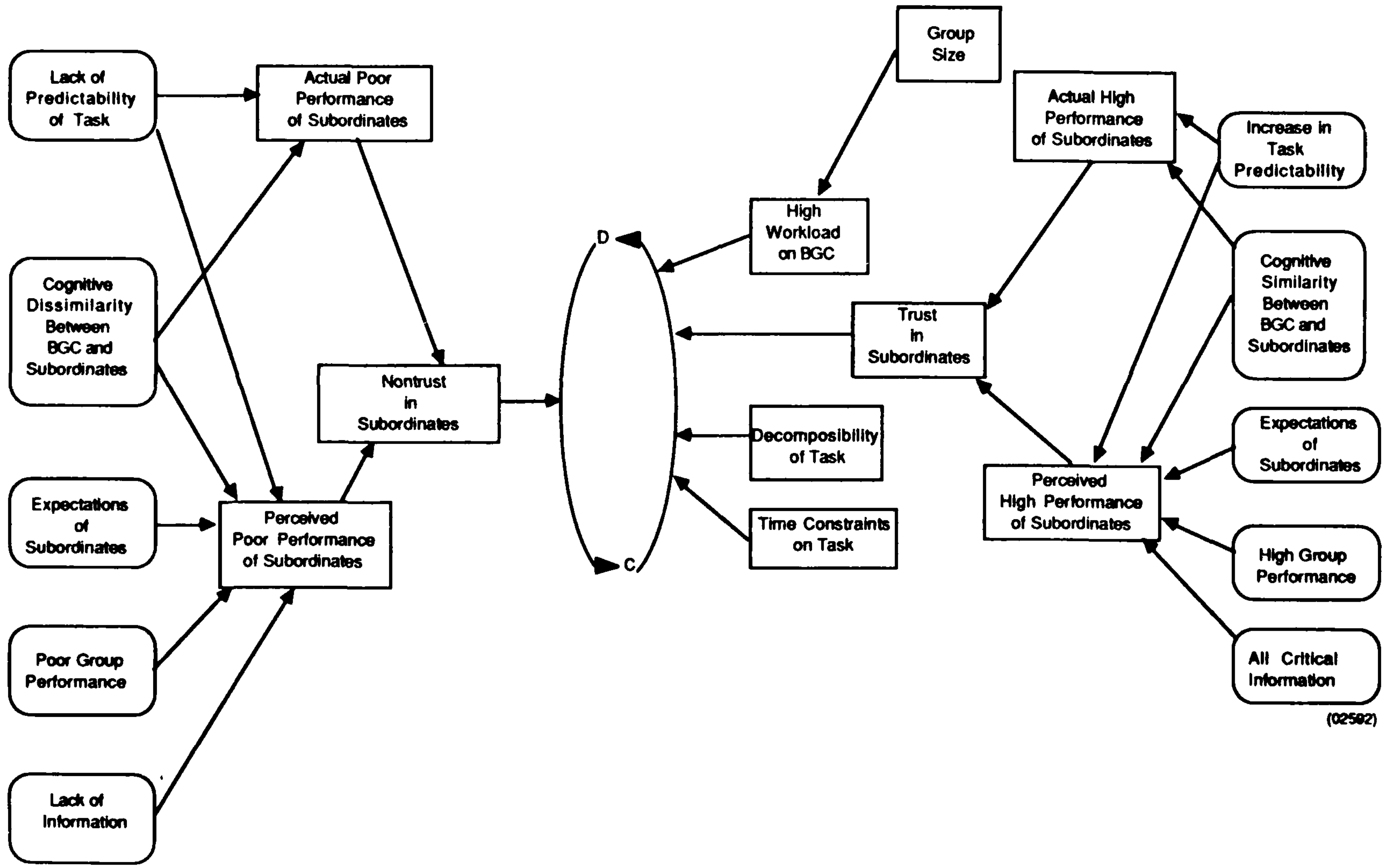
EXPERIMENT 3

INTRODUCTION

This study investigated the conditions under which one can expect a DTDM group to shift from a decentralized to a centralized structure, or vice versa. The issue is based on social psychological research findings which suggest that when a distributed decision-making group experiences failure or distrust, a common response is to move to a more centralized, authoritarian structure (Leavitt, 1951; Porter & Roberts, 1976). Figure 4 shows from the Battle Group Commander's (BGC) perspective the factors which might make an individual shift from a decentralized to a centralized system by taking decision-making authority away from subordinates. In this experiment, the issues of interest are the effect of perceived performance by subordinates and the availability of status/intelligence information on the robustness of decentralized systems.

To implement the experiment, the "star fighter" game of the first experiment was modified so that the actions of the two subordinate starfighter commanders could be simulated, in order to more effectively control the experimental manipulations designed to influence the behavior of the subjects in their role as BGC. The experiment is a 2 (Group Performance) X 2 (Information) factorial design. The BGC has a very demanding task of interpreting intelligence data so that adequate reinforcements may be sent to subordinates to meet subsequent waves of enemy threats.

It is hypothesized that the BGC will take decision-making authority away from his subordinates more frequently in the low group performance condition because he will perceive their performance to be a function of the group's effectiveness. Thus poor group performance will be attributed to the poor performance of subordinates. The information manipulation in this study is such that in one condition the subject will always see the intelligence data that the sector commanders are using to determine the number of friendly fighters to send against the enemy threats. In the other condition, the subject will see the aforementioned intelligence data only if he takes decision-making authority away from his subordinates. It was hypothesized that subjects will be less likely to take decision making authority away from their subordinates in the "information" rather than "no information" condition because they will be better able to assess the cause of the group's poor performance in the "information" condition.



THEORETICALLY-BASED PREDICTIONS AS TO WHAT FACTORS WILL MAKE THE DTDM LEADER SHIFT FROM A DECENTRALIZED TO CENTRALIZED COMMAND NETWORK AND VICE VERSA
FIGURE 4

METHOD

Subjects The subjects were male and female adults ranging in age from 19 to 29, recruited from the Washington, D.C. metropolitan area. There was a total of 12 subjects, three in each condition.

Apparatus A computer-controlled DTDM environment was developed using a VAX-11/750. The DTDM program was written in the C programming language. The task was displayed on a VT 220 terminal. The written instructions for the subjects and questionnaires used in the study are presented in the Appendices.

Scenarios A fictitious crisis scenario based on a futuristic "space war" was developed. The experiment involved a computerized decision-making task in which the subject serves as Battle Group Commander (BGC). The BGC's task was to supply reinforcements to two subordinate Sector Commanders defending a 90-degree sector in space from a series of incoming enemy threats. The experiment manipulated two independent variables, each with levels, forming a 2x2 factorial design:

1. Group Performance-- High (80% probability-of-kill or "Hit Rate") vs. Low (40% Hit Rate)

2. Information-- Available (The BGC console displays the same intelligence information seen by Sector Commanders) vs. Unavailable (The BGC does not see the intelligence information used by sector commanders).

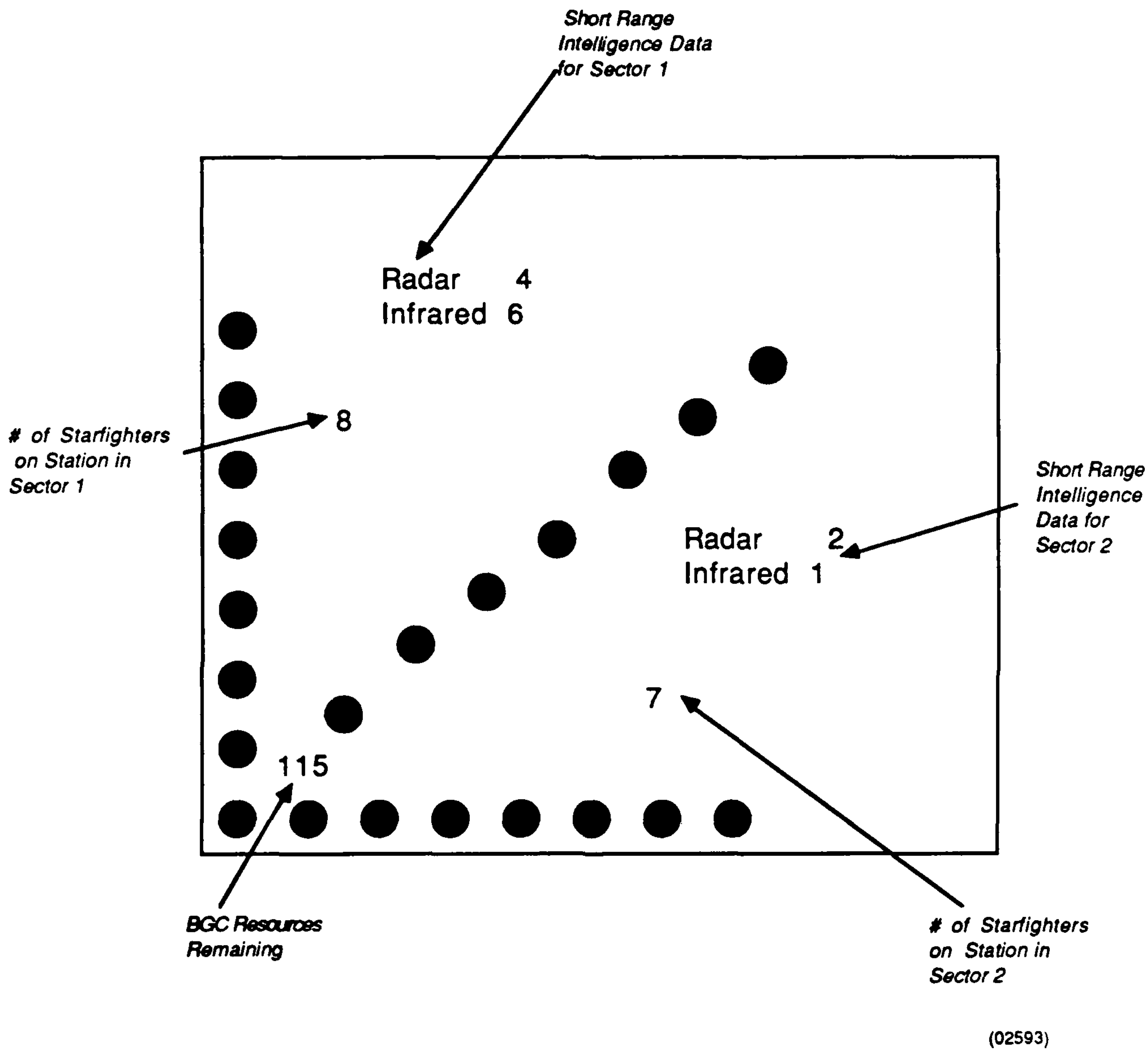
The dependent measures include game related, output and process measures, as well as subjective measures using questionnaires. The experiment simulates a group setting by means of a deception in which subjects were told that they were assigned the role of BGC and play the game with two other individuals serving as Sector Commanders. Subjects were led to believe that these "Sector Commanders" were playing the game at remote sites and interacting via computer network. Each subject participated in two blocks of scenarios. Each block consisted of 16 waves. Each attack wave was 60 seconds long. At the beginning of each block, the subject, as BGC, had 140 fighters available at his disposal. A total of 138 threats was slated to attack the 90 degrees of space that the BGC and his subordinates were charged to defend. The subjects were not informed of the actual number of enemy threats which would be attacking. They were told, however, at the outset of the full scenarios, that they might reasonably expect up to 160 incoming enemy threats to attack the

space under their command.

Prior to their participation in the two blocks, each subject received extensive training, including participation in practice scenarios. Practice scenarios were those in which subjects were led to believe that an experimenter in another room, via another computer terminal, would play the role of the two subordinate Sector Commanders "interacting" with him through his own terminal. Practice and full scenarios also differed in size and duration. Practice scenarios consisted of nine waves of attack . Each wave was 90 seconds in duration. A total of 70 fighters were available at his disposal, and a total of 66 enemy threats was slated to attack the 90 degrees of space that the BGC and his subordinates were charged to defend.

Training of subjects Each subject was thoroughly trained before playing the role of BGC. To begin training, each subject was required to read a booklet describing the tasks and procedures of his role as BGC. After reading the booklet, the subject was allowed to ask questions of the experimenter if he so desired. The second phase of training consisted of oral explanations from the experimenter concerning the interpretation of intelligence data. The subjects were told that there were two types of intelligence data, Long range and Short range. Long-range intelligence data predicted for each sector the number of threats attacking each sector during the following wave of attack. Short-range intelligence data predicted for each sector the number of threats attacking each sector during the present wave of attack. Long-range intelligence data were derived from two sources, which the subjects were told were equally reliable: the "Federation" and the "Alliance." Short-range intelligence data were derived from two sources, which the subjects were told were of equal reliability: "Radar" and "Infrared." Long-range intelligence data could be accessed by the subject simply by requesting it of the computer. Short range intelligence data could be accessed by one of two ways. In the Information Available condition, Short-range intelligence data was constantly present on the BGC's Status-of-Battle Display (see Figure 5). In the Informataion Unavailable condition, subjects could gain access to Short- range data only by taking control of a given sector from the Sector Commander, thereby being given access to the intelligence data normally seen only by him.

In being trained to interpret intelligence data, the subjects were instructed that "pinpoint accuracy" was not expected of them. Instead, they were told that they only needed to make a "reasonable judgment." They were instructed that a "reasonable judgment" was similar to the judgment that a competent meteorologist might make. A meteorologist's forecast for temperature that proved to be at five degrees' variance with the actual temperature, the subjects were told, would still be considered a competent meteorologist. In contrast, a meteorologist whose forecast for temperature



STATUS-OF-BATTLE DISPLAY FOR BATTLE GROUP COMMANDER
FIGURE 5

proved to be at 35 degrees' variance with the actual temperature, the subjects were told, would not be considered competent.

Following the above instructions, the subjects were given a written exercise in order to practice interpretation of intelligence data, beginning with Long-range data. The written exercise presented intelligence reports, and asked the subject to make a judgment on the basis of those reports.

The written exercise for Long-range intelligence data began with the following statement:

> We would like to give you a chance to practice interpreting intelligence data before we continue and you start to participate in the actual game. As the Battle Group Commander, you will need to know how to interpret Long-range data which you receive from the Federation (of which you are a member) and the Alliance. While the data from each of these two sources may differ, they are of equal reliability and should be given approximately equal weight in your judgment.
>
> For example: If the Federation predicts 8 enemy threats for the upcoming wave, and the Alliance predicts 6 threats for that wave, how many threats would you expect? ______
>
> Correct number ______

The "Correct number" *was the number told to the subject after he had made* his own prediction on the basis of intelligence reports. The correct number represented the <u>actual</u> number of threats that arrived on the wave that the intelligence report referred to. Using the meteorology analogy again, the correct number would correspond to the actual temperature of the day for which the meteorologist had made a prediction.

The exercise continued in similar fashion, presenting a series of intelligence reports to the subject, and asking the subject to make a judgment accordingly. The subject was told that he was expected not to predict unerringly the correct number of incoming enemy threats. Rather, the subject was instructed to make a judgment that was in an "acceptable range," much like a meteorologist was expected to make a weather prediction within an "acceptable range." An acceptable range was defined as a number that fell within the numbers predicted by the intelligence sources, plus or minus one. It is important to note that the subject was **<u>not</u>** told of this formula. Rather, he was asked to continue with the intelligence exercise. He was told that the exercise would cease when he had become "sufficiently proficient in interpreting the data." In fact, the exercise was discontinued once the subject had made ten consecutive predictions within the "acceptable range." Again, the subject was **<u>not</u>** told of this formula.

Training would continue in an almost identical fashion in the use of short- range intelligence. The subject was instructed that short-range intelligence data differed from long-range intelligence data in two respects. First, short-range data pertained to the current attack wave, whereas long-range data pertained to the upcoming attack wave. The subject was further instructed that because short-range data was more current, it would be more accurate. Using the meteorology analogy again, the subjects were told that planning with the help of intelligence data was akin to using weather reports to plan a picnic. Long-range data would correspond to the forecasts from the third day of a three-day forecast. In contrast, short- range data would correspond to the current forecast available from the phone company weather line. Accordingly, when the subject was asked to make a forecast within an "acceptable range" on the basis of short-range intelligence data, the acceptable range was defined more narrowly than in the case of the long-range data exercise. Specifically, a prediction in the acceptable range would be a number that fell at or between the numbers predicted by the short-range intelligence sources. Again, the subject was **not** informed of this formula. As in the previous instance, the exercise would continue until the subject made ten consecutive forecasts within the acceptable range.

Once instruction in the interpretation of intelligence data was completed, training continued via three practice scenarios. The practice scenarios each had a different "hit rate." The three hit rates were 40%, 60% and 80%. After the practice scenarios were completed, the subject was led to believe that a computer hookup was made between PGSC local offices and two other remote sites, where other subjects were awaiting to play the role of Sector Commanders under the authority of the BGC. After the "hookup" the two full scenarios ensued. After each of the two blocks of trials, the subject was given a questionnaire, which may be seen in Appendix A. Upon the completion of the session, a final questionnaire was administered, which appears in Appendix B. A debriefing period followed the final questionnaire, during which the deception was revealed. Each subject reported that the contrivances were convincing, and none objected to the arrangements.

RESULTS

One of the major dependent variables of interest is the frequency and the condition under which subjects take decision-making authority away from the subordinate Sector Commanders. Overall, subjects exercised this option (also known as manual defense) rather infrequently (mean in block one and two are 1.25 and 1.66, respectively). There was no statistically significant increase over blocks. With all other variables, Wilcoxon-Signed -Ranks tests did not show any significance across the block differences. It was decided that the two blocks under each condition can be combined for further analysis.

Analysis of the two performance measures (viz., that of frequency of manual defense and adequacy of sending reinforcements) using Friedman two-way analysis of variance (ANOVA) shows no reliable main or interaction effect. The small sample size (three in each condition) in this pilot study partly accounted for the low power in detecting statistical significance results. The general trend on the manual defense data does seem to indicate that subjects are more likely to use manual defense under the low performance condition (Figure 6). With the presence of short-range intelligence under the high performance condition, subjects did not employ manual defense at all. The questionnaire measure of the frequency that subjects find it necessary to employ manual defense shows a similar trend, except under the condition of low performance and no information (short-range intelligence), in which subjects considered manual defense more necessary.

The "adequacy of sending reinforcements," as measured by the presence of fighters on station in a given sector that are within the acceptable range, based on prior long-range intelligence reports, shows a trend which indicates that high performance rate plus presence of short-range intelligence leads to higher performance (see Figure 7).

Further analyses using Kruskal-Wallis one-way ANOVA were conducted on each of the questionnaire items. Main effect due to the performance factor was observed in the following items:

(1) End of session question related to the frequency in which subjects find it necessary to employ manual defense ($p<.05$). This finding corresponds to the actual number of manual defenses in the experiment, although the latter was not found to be significant.

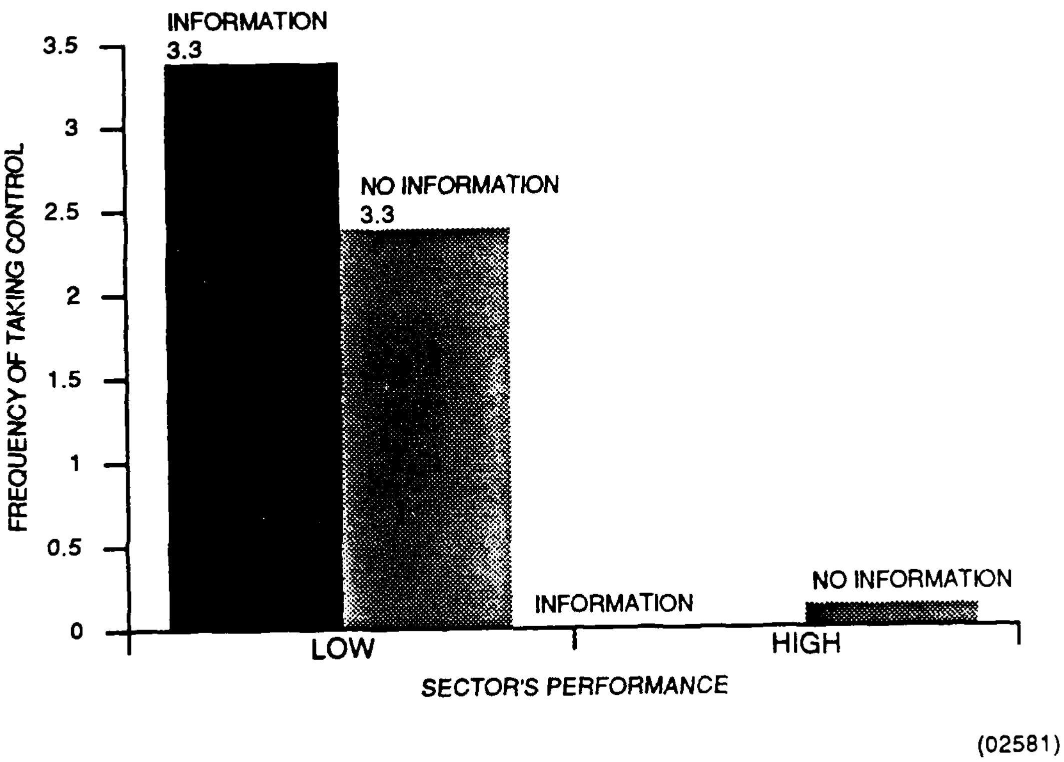
(2) End of block question related to subjects' rating of how well their individual group of Sector Commanders performed during the mission ($p < .05$). This indicates a congruence between the experimental manipulation of the performance variable and subjects' rating of performance of Sector Commanders (see Figure 8a).

(3) The amount of respect subjects had for their Sector Commanders ($p < .01$), which indicates that high performance commanders were rated favorably on this variable.

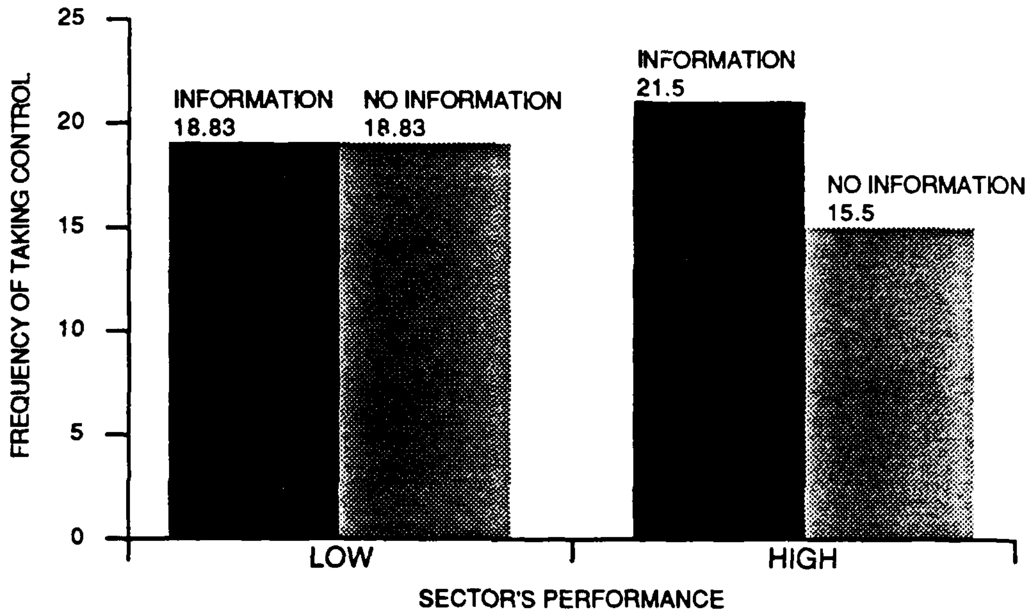
(4) Rating of Sector 1 Commander's performance on the missions ($p < .01$) and rating of Sector 2 Commander's performance on the missions ($p < .01$) show that when performance was high, subjects rated the sector commanders accordingly .

(5) Self-rating of subjects as Battle Group Commander in the missions ($p < .001$). Taken together with (3), this indicates that subjects considered successful mission performance as being a function of their own efforts as well as their subordinates' efforts.

(6) Degree of attribution of the group's performance to Sector Commanders' performance ($p < .05$). Ratings of Subordinate Commanders' performance was in accordance with the group performance manipulation (see Figure 8b). This is also a reflection of the low

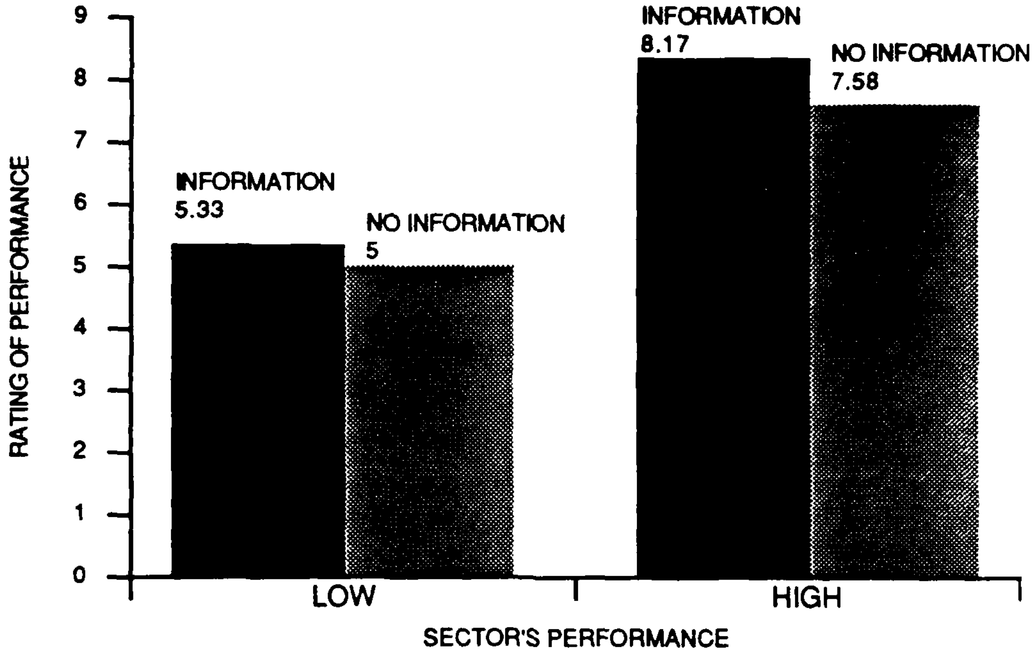


NUMBER OF TIMES STAR FLEET COMMANDERS HAVE TAKEN CONTROL AWAY FROM SUBORDINATES
FIGURE 6

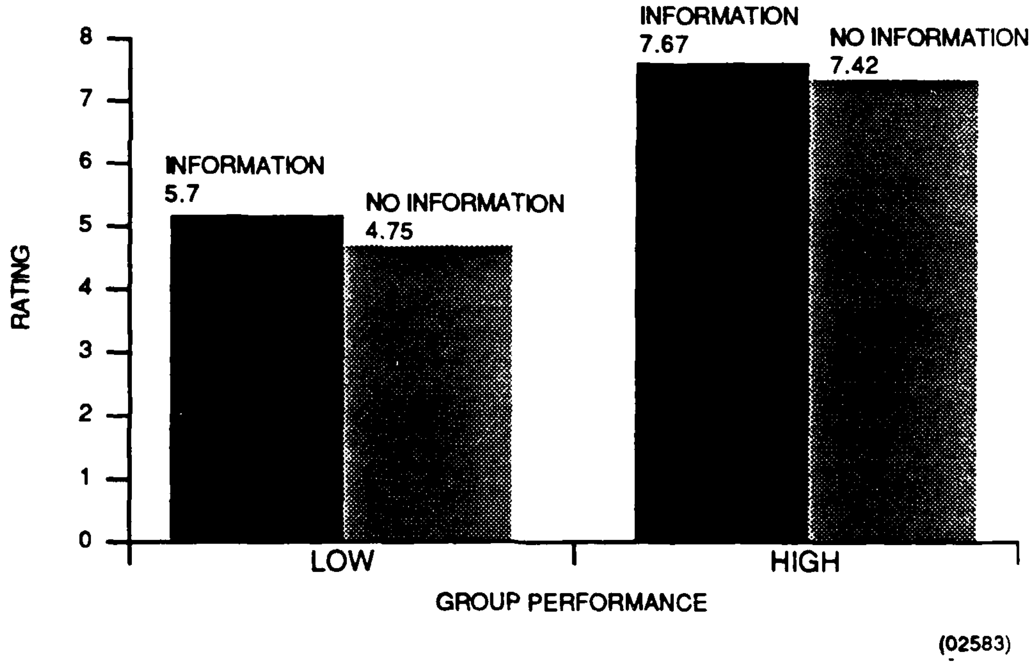


(02582)

NUMBER OF TIMES REINFORCEMENT WAS ADEQUATELY SENT TO THE SECTOR'S (ADEQUATE PERFORMANCE MEASURE)
FIGURE 7



RATING OF HOW WELL ONE'S GROUP OF COMMANDERS PERFORMED
FIGURE 8a



RATING OF THE EXTENT TO WHICH GROUP'S PERFORMANCE CAN BE ATTRIBUTED TO STAR FIGHTER COMMANDERS PERFORMANCE
FIGURE 8b

frequency of manual defense in that successful missions are more likely to viewed as a result of the subordinates' actions, as the subjects themselves seldom use manual defense.

A correlational analysis was carried out on all the relevant dependent variables. Some interesting patterns of relationship emerged.

(1) A high positive correlation was found between workload as measured by end-of-session questionnaire and frequency of manual defense ($r=.678$), i.e., the higher the frequency of manual defense, the higher the perceived workload.

(2) A strong relationship was observed between subjects' confidence in Sector Commander's judgment and how well that particular sector did on the mission ($r=.91$).

(3) A relationship exists between subjects' satisfaction with their own groups and the attribution of groups' performance on one's efforts ($r=.827$).

(4) Subjects' enthusiasm is related to their interest in the game, team spirit, and feeling of involvement (all $r>.5$).

DISCUSSION

This experiment is an attempt to investigate the psychological and organizational robustness of a decentralized DTDM system from the perspective of the Battle Group Commander (BGC). The small number of subjects in this study leads to the low power of the statistical test of significance. This precludes any firm conclusion to be made regarding the results. Nevertheless, several observations are noteworthy, and are suggestive of fruitful directions for future research.

The generally low frequency of manual defense may be explained by the fact that the primary role of the BGC is to monitor and reinforce the Sector Commanders, and not to direct personally the defense of a given sector since this would greatly increase his workload. Despite the low frequency of a centralized mode of operation, some indications existed which show that both performance and information factors had some influence on this variable. Subjects generally employed manual defense relatively more frequently under the low performance condition and especially when information is available. (See Figure 6.) Explanation for this trend from the perspective of cognitive model similarity would suggest that as the BGC and his subordinates share the same cognitive model regarding the immediate threat to the sectors, he can better assess the cause of the group's poor performance and can reasonably attribute it to the performance of individual subordinates. There is, however, a discrepancy between subjective assessment of the need to employ manual defense and the actual relative frequency of manual defense. Subjectively, subjects felt the need to operate in this mode more frequently when information is not available. This tendency may have been inhibited by the demands of the BGC's primary task.

The measure dealing with the adequacy of sending reinforcements to the sectors presents a trend showing that performance is superior under the information-present condition along with perceived high group performance. Thus, the presence of information (i.e.,, short-range intelligence) does seem to enhance the performance of the task of reinforcing the respective sectors.

Results from the subjects' questionnaires in general show the effect of the group performance manipulation. High group performance was generally attributed to the performance of the Sector Commander as well as the BGC's own efforts, which suggests a common understanding of the need for cooperative efforts of the group in achieving a common goal.

Correlational analyses show some indications of the relationship among subjective evaluations of outcome and group process variables, e.g. assessment of overall performance and the BGC's satisfaction with the group as a whole, as well as the relationship between a subject's enthusiasm, team spirit and feeling of involvement. The level of interest and enthusiasm among subjects was further manifested in both their written and verbal comments. The use of subjective measures in this study helps to further illuminate the underlying processes and output variables within the theoretical framework of the DTDM system. This points to the desirability of using a multitrait-multimethod approach (Campbell and Fiske 1959), as advocated at the outset of this project (Adelman, Zirk, Lehner, Moffett and Hall, 1986).

If the general trend observed in this study can be confirmed in future studies, it may be reasonable to suggest that a decentralized DTDM configuration is fairly robust, for only under low performance conditions will it break down. Nevertheless, the effectiveness of the command group configuration may also be dependent on the nature and complexity of the task. Thus, the implications for real-world DTDM environments, in terms of presenting common views of the battle situation to the various sector commanders, and the applications of decision support technology, would benefit from a more systematic study of this issue.

In light of the pilot-study nature of this experiment, as well as the relatively small sample size, the analysis here is not presented as conclusive. Using the game paradigm as in the present study, future studies should explore the issues of interactive group processes, cognitive similarity/consistency, and task type. More stringently defined performance measures are also needed. Attempts have already been made in delineating from the game scenarios further strategy and performance-related measures (see Appendix C).

INTERIM DISCUSSION

Given the interesting pattern of results that emerged from the previous studies, the foundation of the second experiment was expanded. Also, it was decided that the addition of a personality measure might be a useful exploratory device. It was originally planned to use the subjects from Experiment Number Four as participants in a repeat of Experiment Number Three. Unfortunately, this proved to be impossible within the time limits of this contract.

EXPERIMENT 4

INTRODUCTION

The problem of maintaining cooperative decision making in groups sharing resources has been addressed in the psychological literature on social dilemmas (Dawes, 1980; Messick & Brewer, 1983). A social dilemma is a situation in which the individually rational decision is to act in a manner which, when executed by all group members, would lead to both individual and collective failure. For example, in a DTDM group, each commander is aware that it is to his benefit to increase the size of his munitions request to better defend his unit and avoid the risk of loss of personnel. Yet if each commander in a DTDM group acts in the same individually rational manner, the munitions store will be quickly depleted, all units will suffer and the entire group is at greater risk of failure. The area of resource dilemma research has considered the influence of factors such as group size (Bonacich, Shure, Kahan, & Meeker, 1976), communication (Dawes, McTavish, & Shaklee, 1977), information about others' choices (Sweeney, 1973), trust in other group members (Kelley, & Grzelak, 1972), intergroup identity (Brewer, 1979), and reward structure (Pruitt, 1967; Komorita & Barth, 1985) on cooperative decision making. The vast majority of research in this area has examined these factors one at a time, and little is known about the relative importance of the factors or the interaction of two or more factors operating simultaneously. Moreover, few research efforts have examined the effect of group performance effectiveness as it relates to resource use. The fourth experiment was designed to examine the effect of both perceived cooperation and performance (individual as well as group) on the cooperative decision making behavior of a distributed C^2 network in a battle scenario.

It was hypothesized that degree of cooperation would be affected by either individual performance or perceived cooperation. The expectation was that subjects would either cooperate primarily when their performance was high or would tend to behave cooperatively primarily when others had behaved cooperatively.

METHOD

Subjects The participants were 30 male and female undergraduate and graduate students, and college graduates drawn from the Washington, D.C. metropolitan area. Subjects' ages ranged from 17 to 37.

Apparatus Two paper and pencil instruments were administered to the subjects. The first was a

series of 48 game problems, an expended version of the questionnaire used in Experiment Number Two. The second instrument was a personality scale (Form A of the Eysenck Personality Inventory [Eysenck and Eysenck, 1964]). These instruments are in Appendix D and Appendix E, respectively. The written instructions for the experiment is also included in Appendix D.

Game Scenario As in Experiment Number Two, this study required subjects to study a set of battlefield scenarios in which a group of three sector commanders were required to defend a 90-degree area in space. Each commander was responsible for one 30-degree sector and the enemy attack was assumed to be equal across all three sectors. Resources were allocated based on the requests made by each sector. If each commander requested one-third of the available resources, each would receive one-third. If, however, any sector requested more than one-third, the additional ships would be subtracted from the remaining sectors' shares. Thus, when a subject received one-third of the available ships, the other members of the group would be defined as "cooperative." When a subject received less than a one-third share, at least one member of the group would be defined as "noncooperative."

On each trial, the subject was given a brief description of the last wave of attack. The description included the three independent variables of interest: (1) Individual performance--identified as 20%, 40%, 60% or 80% hit rate (in contrast to simply 40% or 80% in the previous study); (2) Group performance--identified as either 20%, 40%, 60% or 80% hit rate; and (3) Resources received, identified as 20%, (less than equal share), 33% (equal share) and 50% (greater than equal share). Scenarios were constructed such that all possible combinations of the independent variables were represented across the scenarios, which were administered to subjects in random sequence. The dependent variable (Resources requested) was expanded beyond the dichotomous choice used in Experiment Number Two. Subjects selected from a number of options ranging from 10% to 90% in 10% increments. This was done to allow subjects to make equal, noncooperative or altruistic choices--options not available in the pilot study, but necessary to completely model the choices logically available.

RESULTS

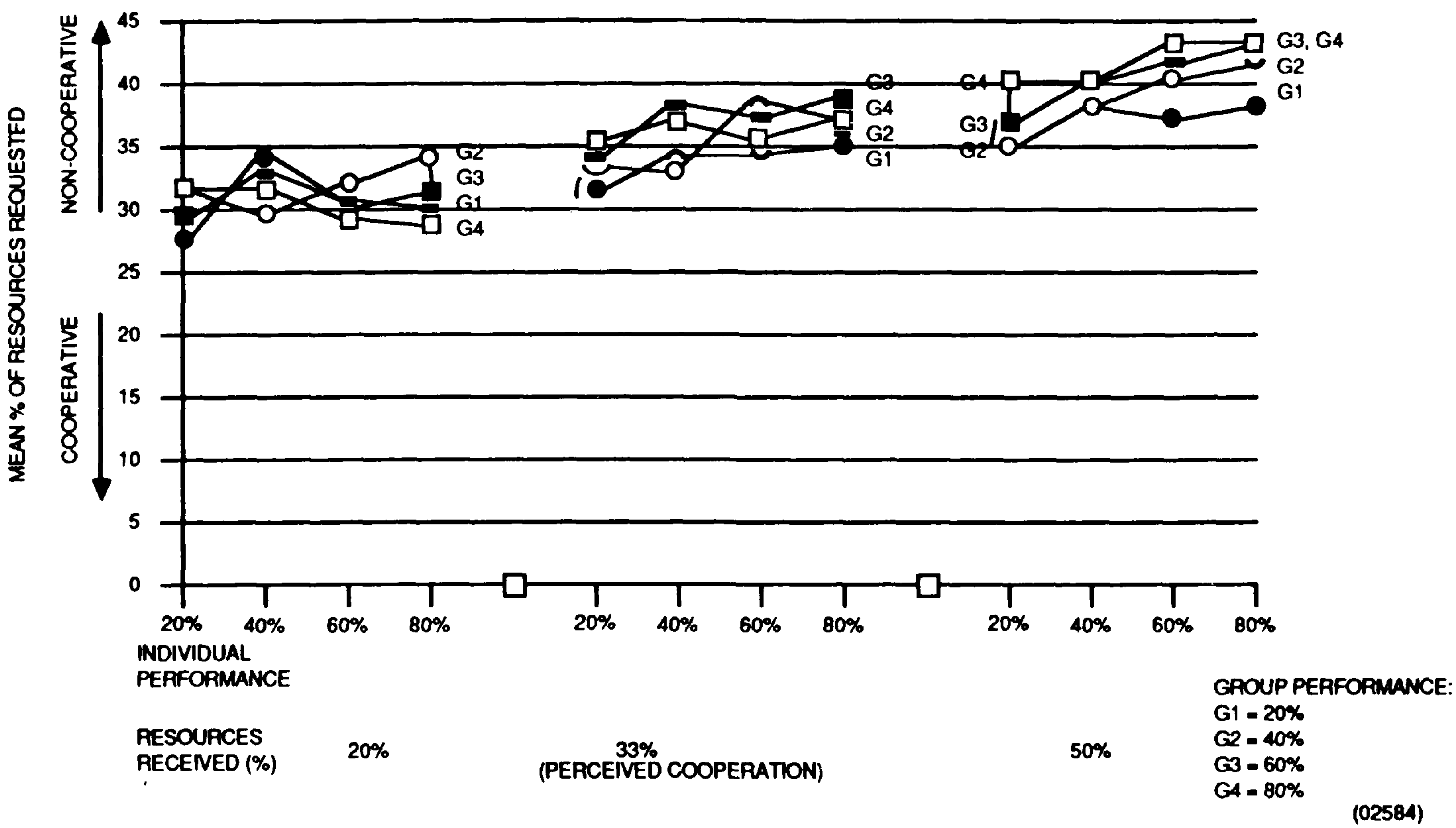
A 4 (group performance) x 4 (individual performance) x 3 (resource received) Analysis of Variance (ANOVA) was performed on the data. First, there was a significant difference within subject effect of the resource factor, $F(2,58)=37.27$, $p < .01$, reflecting an inverse relationship between the level of cooperation (i.e., resources requested) and the level of resources received.

The mean percentage of resources requested at each resources-received level for all combinations of group and individual performance levels is depicted in Figure 9. As can be seen in this Figure, there is an increasing trend of noncooperation as resources received (perceived cooperation) increases.

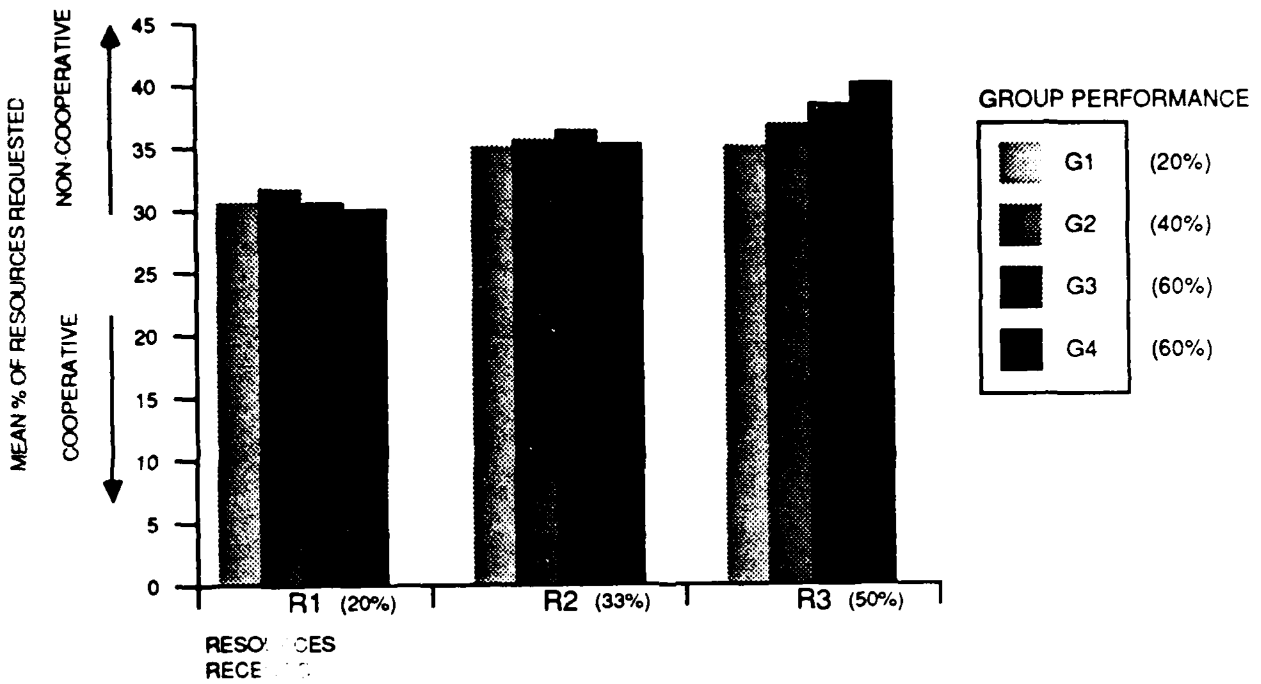
An interaction effect between the group performance and resources received factors was found to be significant, $F(6,174)=5.27$, $p < .01$. The joint effect of group performance and resources received collapsing across the individual performance factor (see Figure10a) indicated that the mean amount of resources received was similar in all group performance conditions at the first level of resources received (20%) and that only at the high recources-received level did the differential effect of group performance become more apparent. Thus, under the high resources condition, the higher the group performance, the less cooperative subjects become, regardless of the individual performance level. A significant interaction was also found between individual performance and resources received, $F(6,174)=3.65$, $p < .01$ (see Figure 10b).

As shown in Figure 9, there is a tendency towards more cooperation when subjects had received less than their fair share of resources. This particular effect had also been reported in Experiment Number Two. In that experiment this effect was <u>more</u> evident when the individual performance was high relative to group performance under the perceived cooperation condition (i.e., 33% resources received). The present study found that, overall, subjects are more cooperative under low resource situations. To further delineate this relationship, a frequency analysis was conducted by tabulating the relative frequencies of cooperative behaviors (i.e., the number of times resources requested were 30% or less in each scenario). Figure 11 shows the proportion of cooperative responses under conditions of different levels of perceived cooperation for four different situations. It is evident from this figure that cooperative behavior is a decreasing function of perceived cooperation. Subjects chose to cooperate more frequently when their fellow commanders had been noncooperative (i.e., the subjects received less than one-third of the resources on the previous wave of attack). It might be that even when they have received less than their fair share of resources (condition R1 in Figure 11), they chose to be cooperative with the hope that they would receive 33% of the resources and be able to increase their performance over the previous trial.

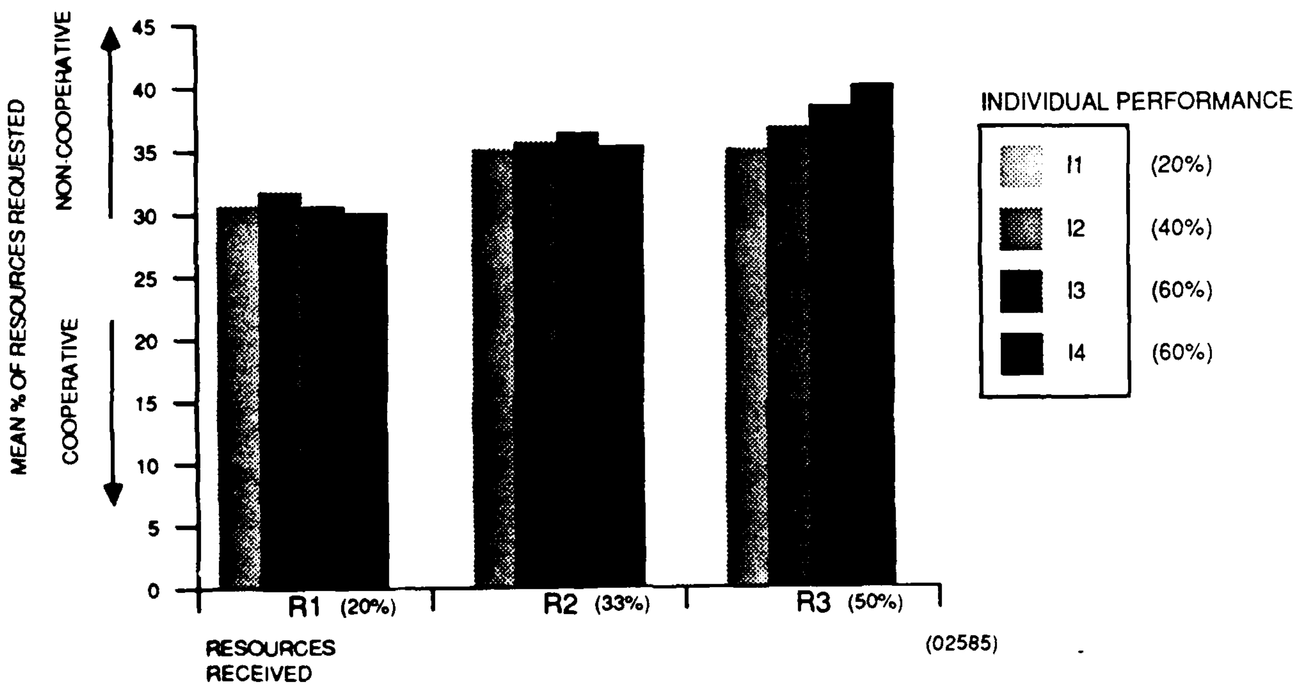
Interestingly, when individual performance is less than group performance ($I < G$) subjects are less cooperative in general. Within this scenario, when the subjects had received 33% of the resources (R2: perceived cooperation), they cooperated less often than in other scenarios. In this situation, more subjects inflated their requests, presumably believing that they could better contribute to the group by improving their individual performance even if this meant depriving other sectors. When



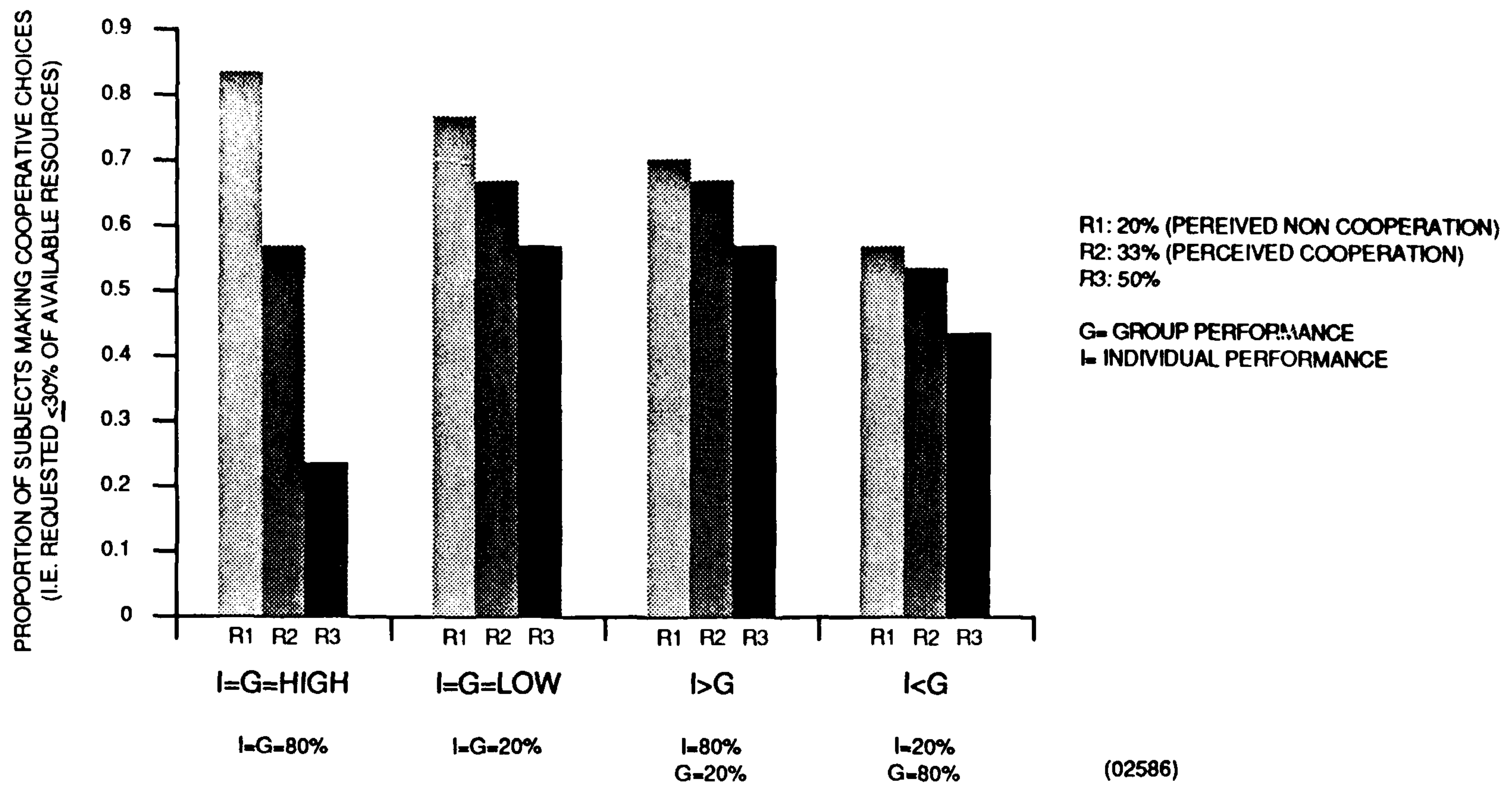
MEAN PERCENTAGE OF RESOURCES REQUESTED AS A FUNCTION OF GROUP & INDIVIDUAL PEFORMANCE
FIGURE 9



RESOURCES REQUESTED (MEAN %) UNDER DIFFERENT LEVELS OF GROUP & RESOURCES RECEIVED CONDITION
FIGURE 10a



RESOURCES REQUESTED (MEAN %) UNDER DIFFERENT LEVELS OF INDIVIDUAL PERFORMANCE & RESOURCES RECEIVED CONDITIONS
FIGURE 10b



PROPORTION OF COOPERATIVE CHOICES UNDER DIFFERENT SCENARIO CONDITIONS (BASED ON HIGH AND LOW EXTREMES OF GROUP AND INDIVIDUAL PERFORMANCE LEVELS)

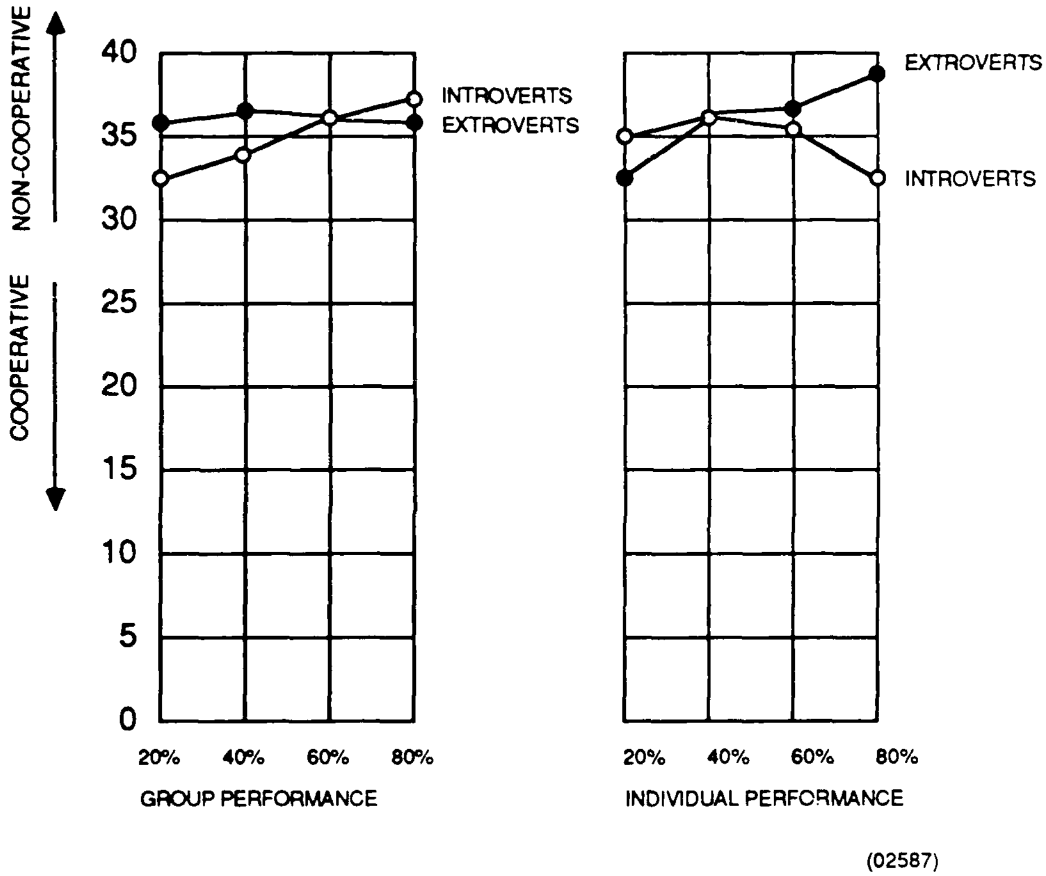
FIGURE 11

individual performance is higher relative to group performance (I > G), more cooperative responses occurred than when individual performance is less than group performance (I < G). This observation, taken together with significant interaction between group and resources and individual and resources, may tend to indicate that the group performance and individual performance factors are being considered together in conjunction with the resource factor in the decision for requesting resources. This is consistent with the observations in the second experiment that subjects had not independently interpreted the resources received in each scenario as an indication of how cooperative other sectors had been. Instead, they relate the resources-received information to individual and group performance information to come up with some kind of "return on investment" concept. Thus, given high resources received in the previous scenario, if the group performance is low relative to individual performance, less cooperation was shown by the subjects (I<G & R3).

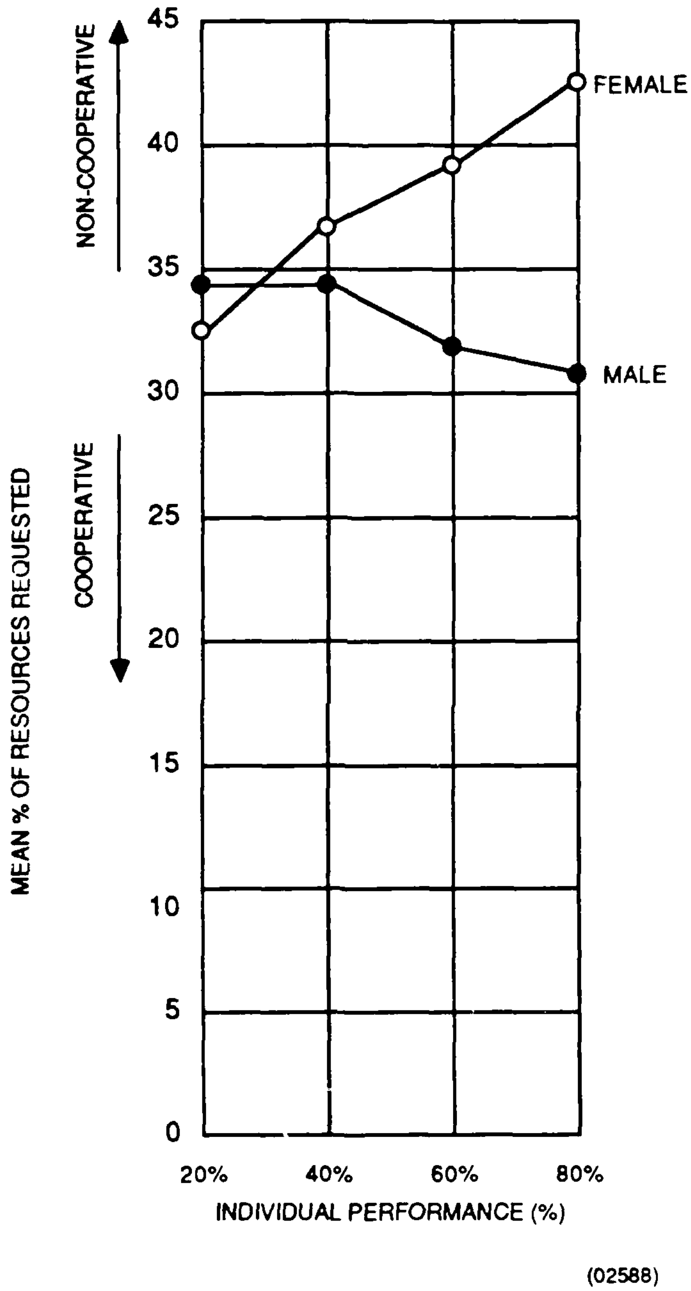
To further analyze the effects of the independent variables on resource requests, ANOVAs were performed using the extroversion personality dimension and gender as grouping factors. For the personality dimension, the median score of 14 of the 30 subjects was used as a cut-off point to differentiate between extroverts and introverts; this resulted in 17 extroverts and 13 introverts.

Similar to the findings reported earlier, there were significant effects due to the resource factor, $F(2,56)=35.12$, $p < .01$; interactions between group performance and resource factors, $F(6,168)=5.24$, $p < .01$; and individual and resource factors, $F(6,168)=3.59$, $p < .05$. In addition, a three-way interaction between personality, group, and individual factors was significant, $F(9,20)=3.42$, $p<.01$. As shown in Figure 12, under low group performance conditions, extroverts were less cooperative, while under high individual performance condition, extroverts are also less cooperative compared with introverts.

Since the sample was equally divided between males and females, an additional analysis was carried out using gender as a between-subject grouping factor. As in the previous analyses, the resource factor, resource- by-group, and resource-by-individual interactions were all significant at the .05 level. A significant effect due to gender grouping was observed, $F(1,28)=4.21$, $p < .05$. In general, male subjects were more cooperative than female subjects. A reliable interaction between gender and the individual performance factor was also observed, $F(3,84)=3.17$, $p < .05$. As can be seen in Figure 13, male subjects tended to be more cooperative when individual performance was high. This observation seems to bear some relationship to the trend found in the introverted group, in that under high individual performance condition, introverts are more cooperative.



MEAN PERCENTAGE OF RESOURCES REQUESTED AS A FUNCTION OF EXTROVERSION & INTROVERSION WITHIN LEVELS OF GROUP & INDIVIDUAL PERFORMANCE
FIGURE 12



MEAN PERCENTAGE OF RESOURCES REQUESTED AS A FUNCTION OF GENDER AND INDIVIDUAL PERFORMANCES
FIGURE 13

DISCUSSION

The finding that amount of resources requested is positively related to the resources received variable (i.e., subjects tended to opt for less cooperative behavior when they had received more than their fair share of resources) and the interaction effects of performance and resource variables may be observations that are unique to the present experimental paradigm. The paradigm used in this experiment bears some resemblance to the take-some game used in previous research on social dilemma (Hamburger, Guyer, & Fox, 1975). The take-some game is characterized by situations in which individuals must decide how much of a shared resource to take for themselves. Despite this apparent similarity, some key differences remain. First, studies on social dilemmas have traditionally not been concerned with the issue of relative performance of group and individuals as it relates to cooperative behavior. Second, the present study used questionnaires, thus, anonymity of choice is assumed. Studies have found that public disclosure of choice leads to higher rates of cooperation (Jerdee & Rosen, 1974, Fox & Guyer, 1978). To the extent that subjects do not expect others to defect or otherwise be uncooperative, they may desire to be "free riders" (Marwell and Ames, 1979). There can also be a desire to maintain consistency of behavior (Vestewig, 1978), therefore, the higher the resources received in the previous scenario, an equally high resource amount will be requested. Third, previous studies have found that subjects cooperate less in larger groups than in smaller ones. Rapoport, Chammah, Dwyer, & Gyr (1962), and Bixenstine, Levitte, & Wilson (1966) reported a low degree of cooperation in three- and six-person games than comparable two-person prisoner's dilemmas. In addition, each participant in a two-person group can, by choosing not to cooperate, punish the other member, thus influencing others' decisions in the next scenario. This is apparently not a strategy adopted by the subjects in this experiment. The nature of the scenario problem is such that each of the 48 problems are considered independent, and subjects are expected to assume command of one of the sectors at different times.

In a recent study by Brewer & Kramer (1986) using a replenishable resource dilemma game, they found that different versions of the task with identical payoff structures did not evoke the same level of cooperative choices. The results were interpreted in terms of Tversky & Kahneman's (1981) decision framing. Thus when decisions are framed in terms of gains, individual preferences reflect risk aversion, whereas when the decisions are framed in terms of losses, preferences reflect risk tolerance. Attempts to identify the more or less risky choices for different situations still remain illusive (Rutte, Henk, Wilke, & Messick, 1987). The task used in the present study, although it framed the resource variable in terms of gains, involves other factors in determining the subjects' responses. The relatively less cooperative decisions under the high resource condition reflect the influence of both the group and individual performance factors. Thus under the

condition of cooperation (wherein subjects had received in the previous wave at least 33% of resources available), subjects are less cooperative if their own sector's performance is less than that of the group as a whole. Compared with the previous situation, subjects in general tended to be more cooperative when individual performance is higher than that of the group. It would seem then that concern with individual performance tends to take precedence over concern for group performance. It is reasonable to postulate that subjects seem to be operating with some kind of "mental accounting" expressed in terms of a simple assessment of "return on investment." Thus under low resource condition, when individual performance is less than group performance, less cooperative decisions are exhibited. Conversely, when resources received in the previous wave of attack were high, high individual performance relative to group performance tends to evoke more cooperative choices. It has been suggested that the cooperative choices under such circumstances can be viewed as rewards to other members of the groups (Komorita, 1987). A point can be made that the notion of noncooperation as operationally defined as requesting more than 30% of the available resources, is somewhat restricted. In an actual resources sharing situation, a person requesting more than 30% of the resources may be basing his decision on some other factors such as perceived need for greater resources and with the goal of enhancing overall group performance.

With regards to gender groupings, previous research on Prisoner's Dilemma has shown that males are more likely than females to adopt a cooperative strategy, although this difference typically emerges only after the game has been played for a large number of trials (Carment, 1974; van de Sande, 1973). An early study by Rapoport & Chammah (1965) reported that male pairs were more cooperative than female pairs (although there was no difference in the number of cooperative choices between the members of male-female pairs). Some issues have been raised as to whether the notion of "competition" and "cooperation" in these studies really reflect their real-life counterparts (Deaux, 1976; Maccoby & Jacklin, 1974). Of more immediate relevance to the present study are the findings that male and female subjects employed different interacting styles in Prisoner's Dilemma game situations (Hottes & Kahn, 1974; Vinake, et. al., 1974), in that the primary emphasis of male participants is to concentrate on developing tactics (i.e., cooperation) that will insure that their outcomes are maximized while females are less concerned with the game per se than with the interpersonal aspects of the situation.

It is possible that this experiment has uncovered genuine individual differences in cooperative decision making. This issue may need further examination in terms of using a more direct measure of response style or risk taking tendency with respect to performance and cognitive similarity/dissimilarity factors in group decision making situation.

CONCLUDING DISCUSSION

The results of the last two experiments point to the importance of performance (both individual and group) as mediating factors influencing decision processes. From the viewpoint of a global commander, these processes would include the decision to shift from a distributed to a centralized command network (or vice versa). From the viewpoint of subordinate commanders, these include decisions to make cooperative or noncooperative requests for shared resources. In the third experiment, subjects in the role of Battle Group Commander (BGC) who perceived subordinate's performance to be low were more likely to shift to a centralized mode of operation. The robustness of decentralized DTDM systems thus is affected by poor performance of subordinates. The shift to centralized mode of operation in turn increases the BGC's cognitive workload. This clearly suggests the desirability of a system to be able to support both a global commander's <u>assigned</u> tasks (i.e., those tasks which are uniquely his in a decentralized network) and his <u>assumed</u> tasks (i.e., those additional tasks which he takes upon himself as a result of centralizing responsibilities).

The findings of the second experiment were amplified by those of the fourth. In both experiments, the relationship between resources received and performance (both group and individual) and their effect on cooperation was of considerable interest. As individual performance increased or decreased relative to group performance, cooperation increased or decreased accordingly. (In this regard, this project distinguishes itself by stressing the importance of looking at performance and resources in <u>conjunction</u> with one another, rather than in <u>isolation</u> from one another). See Figures 9 and 11 for a depiction of these interactions. One possible explanation for these phenomena is that of competing agendas or priorities operating within the subordinates. On the one hand, subordinates want to perform well as individuals. Thus, when individual performance is low relative to group performance, cooperation tends to break down as the subordinate tries to "catch up" with the rest of the group. This could account for the noncooperative behavior in the presence of high resources. Perhaps the subordinate interprets his receipt of the lion's share of the resources as something he "deserves." He deserves his larger portion either because his performance is poor (and he needs the extra resources to hold on and then to catch up to his fellows); or he deserves a larger portion because his performance is superior to that of his fellows, and therefore deserves to be rewarded for his superior performance. In a low resource condition, it was observed that cooperative behavior tends to increase. Perhaps this is so because the subordinates (who are involved in a life-and-death struggle <u>with</u> each other <u>against</u> a common threat) see the lack of resources as a sign that the group is in dire straits. In such a situation, perhaps a subject would be more likely to consider group <u>survival</u> over individual performance. Thus the two "agendas" or competing sets of priorities within a subordinate are a desire for personal achievement, in

competition with the desire for group survival and success. This would suggest the value of further examination of possible means to encourage group identity and group goals. This in turn raises the issues of incentives for cooperation, group process and cognitive consistency, each of which will be discussed shortly.

Regarding incentives for cooperation, the first experiment indicated that an incentive structure (especially group-oriented) significantly affected the frequency of voluntary cooperative acts. A centralized command network affected the increase in the proportion of requests for support that were accepted by the subordinate sectors. However, subjective assessment of subjects still showed a preference for a decentralized command network over a centralized network. Further work should be done to explore the conditions for the integration of these two seemingly disparate trends.

Taking together the results of the third and fourth experiments, it seems that the interacting process/pattern in a DTDM group is mediated by the views of both the BGC and his subordinates. Questions can be raised as to under what circumstances the behavioral tendencies observed in the above- mentioned experiments work to facilitate the proper functioning of a distributed system. For example, it would be valuable to identify under which performance or resource use patterns that centralized control would be willingly accepted by group members, and how actual performance of the tasks at hand can be enhanced. On the social psychological level, it has been found that people will opt for structural change when the group fails to deal efficiently with a required task (Rutte, & Wilke, 1984; Samuelson, Messick, Rutte, & Wilke, 1984). Messick, Wilke, Brewer, Kramer, Zemke, & Lui (1983) found that when subjects thought that others were overusing the resources, causing the pool to drop, 60% to 70% of them favored changing the system and electing a leader. Apart from these group dynamics characteristics of a command network, other group processes may be facilitated by features in the computer-mediated communication context (Siegel, Dubrovsky, Kiesler, & McGuire,1986) in terms of interactive display design. They involve issues of display characteristics and data base features which provide a shared view of battle status. This in turn poses the question of cognitive similarity.

More rigorous manipulation of the cognitive similarity variable is needed in view of the increased potential of introducing automated decision aids in group decision making (DeSanctis & Gallupe, 1987). Cognitive model similarity and consistency can be an important intervening variable in these computer-mediated decision support systems. As Athens (1982) pointed out, commanders interacting with each other tend to develop "mutual expert models" in an attempt to provide a common view of the global situation. The hypothesis was that the greater the similarity in the two

commanders' cognitive models, the better the communication and coordination of their tactical decisions.

Future research should continue to emphasize the utility of the multiple methods of measurement in investigating the interacting patterns of command group functioning by delineating through experimental game scenarios the strategy and performance outcomes of successful and unsuccessful groups. This also requires further development of techniques in coding the interacting and communication processes (Hirokawa, 1982; Burleson, Levine, & Samter, 1984).

As was observed earlier, much of the research in distributed C^2 networks emphasizes mathematical optimization techniques. Nevertheless, other DTDM researchers have taken a more "psychological" rather than "mathematical" approach to the domain. Such an approach represents a step closer to the real world. The PGSC team numbers itself among those who have committed themselves to making the transition to real-world applications by focusing on the "suboptimal" users (i.e., human beings) of theoretically optimal systems. We distinguish ourselves from this group, however, on the following points. The first is the attempt to examine in depth the contexts and processes involved in the maintenance of a distributed command network, as well as the possible shift to centralized command authority. The second is the investigation of the underlying psychology of the promotion or discouragement of cooperative resource use. Finally, we have sought to examine and integrate these issues from the perspective of both the global commander and the subordinate commander. By virtue of our findings, we can say that the development of a complete psychological theory of DTDM should be built on a foundation which includes individual and group processes, an understanding of the dynamics of cooperative behavior, recognition of the need for clear communication of viewpoints, support of common goals and mental models, and a strong appreciation of the difficult but promising issues surrounding the introduction of sophisticated decision support, graphic display and telecommunication technologies.

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APPENDIX A

END OF BLOCK QUESTIONNAIRE

1). Please rate how well your group of Commanders as a whole performed during this mission.

Extremely Poor					Average					Extremely Well
0	1	2	3	4	5	6	7	8	9	10

2). Please rate how well you think Sector 1 did on this mission.

Extremely Poor					Average					Extremely Well
0	1	2	3	4	5	6	7	8	9	10

Please explain your rating-

3). Please rate how well you think Sector 2 did on this mission.

Extremely Poor					Average					Extremely Well
0	1	2	3	4	5	6	7	8	9	10

Please explain your rating-

4). Please rate how well you think you as a Star Fleet Commander did on this mission.

Extremely Poor					Average					Extremely Well
0	1	2	3	4	5	6	7	8	9	10

Plase explain your rating-

5). How much do you attribute the group's performance to your performance?

Not at All										Entirely
0	1	2	3	4	5	6	7	8	9	10

6). How much do you attribute the group's performance to your Star Fighter Commander's performance?

Not at All										Entirely
0	1	2	3	4	5	6	7	8	9	10

7). How much do you attribute the group's performance to the enemy's performance?

Not at All										Entirely
0	1	2	3	4	5	6	7	8	9	10

APPENDIX B

END OF SESSION QUESTIONNAIRE

Sector#_______
Group#_______

1) The other commanders seemed to interpret the intelligence data in the same way that I did.

Very Strongly Disagree					Neither					Very Strongly Agree
0	1	2	3	4	5	6	7	8	9	10

2) The information I received from Intelligence sources predicting the probability of enemy attack for Sector 1 and Sector 2 was very useful.

Very Strongly Disagree					Neither					Very Strongly Agree
0	1	2	3	4	5	6	7	8	9	10

3) During this game, how often did you find it necessary to interrupt the Star Fighter Commanders to order them to vector ships.

I Never Needed to Issue Orders										I Needed to Issue Orders Often
0	1	2	3	4	5	6	7	8	9	10

Please discuss the times you found it necessary to order them to vector ships. Please give your reasons.

Please discuss the times you did not order them to vector ships. Please give reasons.

Sector #________
Group #________

4) In your opinion, was it more effective to supply reinforcements and let each Star Fighter Commander vector ships or was it more effective to order the Star Fighter Comanders to send ships. Please explain your answer.

5) Based on your experience in this game, do you prefer to allow each Star Fighter Commander to vector ships without your order or would you prefer to order the Star Fighter Commanders to vector a certain number of ships? Please explain your preference.

6) As the Star Fleet Commander in this game, you had a number of things to think about and pay attention to in your work. Please rate how light or heavy you found the workload. Please describe.

Very Light Workload					Average					Very Heavy Workload
0	1	2	3	4	5	6	7	8	9	10

7) Based on your experience in this game, did you develop any rules of thumb or guidelines to help you? Please describe.

Sector#________
Group#________

8) Please rate your level of confidence in Sector 1's judgements throughout this game.

Extremely Low					Average					Extremely High
0	1	2	3	4	5	6	7	8	9	10

Please explain your rating-

9) Please rate your level of confidence in Sector 2's judgements throughout this game.

Extremely Low					Average					Extremely High
0	1	2	3	4	5	6	7	8	9	10

Please explain your rating-

10.) How pleased are you to be a member of this group?

Very Displeased					Average					Very Pleased
0	1	2	3	4	5	6	7	8	9	10

11.) How much did you like being the Star Fleet Commander?

Dislike Greatly					Neither Like or Dislike					Liked Greatly
0	1	2	3	4	5	6	7	8	9	10

12.) How enjoyable did you find participating in this study?

Very Unenjoyable					Average					Very Enjoyable
0	1	2	3	4	5	6	7	8	9	10

13.) How much respect do you have for your Star Fighter Commanders?

Little Respect					Average					Great Respect
0	1	2	3	4	5	6	7	8	9	10

14.) How appealing did you find this experience?

Very Unappealing					Average					Very Appealing
0	1	2	3	4	5	6	7	8	9	10

15.) How inclined would you be to work with this team again?

Very Disinclined					Average					Very Inclined
0	1	2	3	4	5	6	7	8	9	10

16.) How enthusiastic were you about being a member of this group?

Very Unenthusiastic					Average					Very Enthusiastic
0	1	2	3	4	5	6	7	8	9	10

17.) How interesting did you find participating in this study?

Very Uninteresting					Average					Very Interesting
0	1	2	3	4	5	6	7	8	9	10

18.) How much team spirit did you feel for the group?

None					Average					Great Deal
0	1	2	3	4	5	6	7	8	9	10

19.) How strongly did you feel a part of the group?

Not at all					Average					Very Strongly
0	1	2	3	4	5	6	7	8	9	10

20.) Please write any other comments you might have regarding this game.

APPENDIX C

1.0 INTRODUCTION

The present Appendix answers the question, "What happens in DTDM?", in terms of inputs to and outputs from the DTDM computer program. Inputs to the program either are "canned," i.e., taken from previously made up files that are available to the computer during run time, or are the direct result of user interactions during run time.

The "user" is, of course, the subject of the psychological experiment that the DTDM computer program supports. Comparing the DTDM program inputs with the outputs enables certain key aspects of the subject's behavior to be observed, measured, and evaluated. The results may be applied to testing hypotheses about how the subject's behavior will vary with manipulations of the experimental variables of interest. Because both the "canned" inputs and the subject's actions are recorded as the experiment progresses, the results of the experiment may be directly input to special-purpose data-reduction programs designed to analyze the experiments.

This Appendix describes such a data-reduction program. More precisely, it describes the outputs of such a program resulting from running the experiment on one particular subject. From this description the reader will infer, to a good enough approximation for present purposes, what the DTDM program does, and what the data-reduction program does, in general, and for an arbitrary subject.

Outputs of the data-reduction program are intended to let the experimenter see, more or less at a glance, what the subject did during the experiment. Although hypotheses about how the subject would act were, of course, made prior to running the experiment, a clear depiction of what actually happened may be expected to yield both insights into the present experiment and fruitful additional or alternative hypotheses to be tested in subsequent experiments. To help the experimenter monitor ongoing performance, the data-reduction program contains various evaluations of the subject's actions during the course of the experiment that are included right along with a statement of the actions that are evaluated. For instance, at various times during the experiment it is appropriate for the subject to "send" aircraft to "Sectors 1 and 2"; the subject's performance is rated "PLUS," "MINUS," or "CHECK" according to whether the subject sends too many, too few, or an acceptable number of aircraft. This rating is shown side by side with the acceptable limits and the

numbers of aircraft actually "sent." Finally, certain summary tables and statistics are presented at the end of the output.

Outputs of the data-reduction program can be input to further computer programs for additional processing--for example, for running statistical tests using various available statistical "packages." Also, since it is flexibly coded, the data-reduction program may be readily modified to incorporate additional summaries, measures, or evaluations. (Note that running a modified data-reduction program does not necessitate rerunning an experiment, since the necessary inputs to the data-reduction program--viz, the inputs and outputs to the corresponding experiment--already exist and remain the same.) Since the data-reduction program describes and analyzes the performance of a subject or sequence of subjects (each subject within the sequence being taken in turn), it may be appropriate to modify the data-reduction program when new measures or evaluations of the performance of individual subjects are to be made, using the already-existing data. Outputs of the program may be used by themselves, or as inputs to additional programs or calculations, to compare the performance of the various subjects or to derive statistics or test hypotheses involving the performance of the collection of subjects as a whole.

2.0 DISCUSSION OF THE HEADING

The first line of output from the data-reduction program contains the heading:

```
Thu Oct  2 21:19:59 EDT 1986;  Scenario 1.4;  Data     01;  Group    03
```

The date and time here refer to when the experiment was begun for this particular subject--viz, the second of twelve subjects participating in the experiment. The subject number is equal to the "Group" number (here, 03) minus 1: the "Groups" in the overall experiment are numbered 02 through 13, and each "Group" consists of exactly one subject.

"Scenario 1.4" identifies the particular scenario (the VAX file "scen1.4") and attrition table (the VAX file "matrix1.4") used with the present subject. The scenario file determines a scenario consisting of some number of "waves." Successive "waves" correspond to successive lines in the file, and so the total number of "waves" is equal to the total number of lines in the file. The columns within any given line in the scenario file determine, successively, for the corresponding "wave": (columns 1 through 4) the short-range intelligence from each of two sources for each of "Sectors 1 and 2" (a total of four columns); (5) number of enemy attackers against "Sector 1"; (6) number of enemy attackers against "Sector 2"; (7) number of defenders sent against the enemy in "Sector 1" in "autodefense mode" (see below); (8) number of defenders sent against the enemy in "Sector 2" in "autodefense mode"; and (9 through 12) the long-range intelligence from each of two sources for each of "Sectors 1 and 2" (a total of four columns). The meaning of these inputs will become clearer as the discussion below proceeds. The meaning and application of the attrition table will be discussed in Section 4.0.

"Data 01" indicates that the short-range intelligence data are visible to the subject throughout the experiment. The only alternative in the present experiment, "Data 00," would indicate that these data are visible only under special circumstances (see the discussion of Wave 4 below). The meaning and usefulness of the short-range intelligence is discussed in Sections 3.0 and 4.0.

3.0 DISCUSSION OF THE FIRST WAVE

The experimental scenario contains some number of "waves" of incoming enemy attackers. The actual number of waves is sixteen, although the subject is not aware of this actual number. He is, however, told the approximate total number of attackers available. In principle, this information would enable the subject to guess the approximate number of waves as the scenario wears on, provided that he refers to the "Performance Data" (discussed in Section 3.0, below) to ascertain the number of attackers expended during the preceding three waves, and keeps count of the attackers remaining.

The onset of each wave is heralded by the message, "Enemy Attacking 1 & 2." That is what the subject sees during the running of the experiment. The corresponding line for Wave 1 in the output of the data-reduction program is:

```
WAVE 1: (TIME 0 THROUGH 59)
```

The start of the other waves is indicated similarly. As suggested by the phrase in parentheses, each wave lasts for just sixty seconds, with Wave 1 beginning at time (second) 0. The length of a wave is determined by a parameter within the DTDM program; though easily changed (by a programmer), it is not intended to be an input to the program.

Immediately after the announcement of a new wave in the data-reduction program output comes a status report. For Wave 1 in the present case this is:

```
STATUS AT BEGINNING OF WAVE:
            A/C AVAIL   SRI
 SECTOR 0        140
 SECTOR 1    0+ 0= 0    0 0
 SECTOR 2    0+ 0= 0    0 0
```

A parameter within the DTDM program determines that the number of friendly aircraft available at the start of the experiment will always be 140. These planes are situated in "Sector 0," which is a supply depot for aircraft to be sent to Sectors 1 and 2. Currently, there is a total of 0 aircraft available at either of the latter sectors. Each such total is expressed as a sum of two numbers, the

first representing the number of aircraft sent from Sector 0 on the wave preceding the last wave, the second representing the number of aircraft sent from Sector 0 on the last wave. Here these earlier "waves" are nonexistent; had there been such waves they would have been labeled "Wave -1" and "Wave 0," respectively, to be consistent with the numbering of the actual waves. The numbers of aircraft sent on each of these [nonexistent] waves is shown as 0: "0+ 0= 0".

Also shown in the status report is the short-range intelligence (SRI) pertaining to the present wave (Wave 1). This information is available to the present experimental subject at any time, without any special action on his part being required, as indicated by the "Data 01" phrase in the header. For some of the other experimental subjects this information is available only when the subject "takes command" of Sector 1 or 2; and then it is available only for the sector that he takes command of. Under which conditions this information is made available to the subject is one of the variables manipulated in the overall experiment. To help the person reviewing the experiment remember what the situation is for any given subject, the data-reduction program includes the SRI information in the initial "status" report if and only if the subject is in the "Data 01" category.

In the present case the short-range intelligence shows that each of two sensors in each of Sectors 1 and 2 reports no incoming attackers during the present wave (Wave 1).

In contrast to the short-range intelligence, the long-range intelligence (LRI) is available at all times to all experimental subjects whenever they choose to consult the appropriate display. The times when this display is consulted, and its contents, are shown in output lines like the next:

```
LRI CONSULTED  FROM   4 THROUGH  10; FROM  58 THROUGH  83
            LRI
 SECTOR 1   7 3
 SECTOR 2   5 0
```

The long-range intelligence predicts the number of aircraft attacking Sectors 1 and 2, respectively, according to each of two intelligence sources (corresponding to the two respective columns under the heading "LRI"). The subject is told that each intelligence source is to be given equal weight in predicting the numbers of attackers in the upcoming wave. It would seem to follow that the "best estimate" of Wave-2 attackers against Sector 1 should be 5; and, against Sector 2 should be 2, 2.5, or 3, depending in part (perhaps) on one's understanding of the problem. This information may

help the subject decide how many reinforcement defenders to send from Sector 0 to Sectors 1 and 2 to meet the next wave and perhaps the wave beyond that. (Reinforcements arriving in Sector 1 or 2 during Wave i may be used in Wave i or Wave (i+1); after that they are "sent home for refueling" and do not re-enter the scenario.) The subject must also decide whether or not to "take command" of Sector 1 and/or Sector 2. If he "takes command" of a sector, he must decide how many aircraft to send against the present incoming wave of attackers, unless he is willing to "relinquish control" in timely fashion; in the latter case, deciding how many defenders to send against the attackers is decided by the DTDM program. More on these decisions later.

In order to find out what happened during preceding waves, the subject must consult a special "Performance" display. During Wave 1 there are no preceding waves, and so there is no need for the subject to consult the "Performance" display. That the subject acted accordingly in the present case is shown in the next output line:

```
PERFORMANCE NOT CONSULTED
```

The subject also did not elect to "take control" (or "take command") of either Sector 1 or Sector 2, as shown by the following two lines:

```
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
```

The implications of "taking command" are discussed later when (during Wave 4) the situation arises.

Shown last in the output corresponding to each wave is the subject's decision regarding supplying ("restocking") defenders to Sectors 1 and 2. In the present case this output is:

```
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
  15     6        1
  16     4        2
```

It was suggested above that a "best estimate" of the number of Wave-2 attackers might be 5 and

2.5, respectively. The subject was told the approximate number of attacking aircraft throughout the total number of waves. The actual total number of enemy attackers is approximately the same as the total number of defenders.

Determining an "optimal strategy" against which to measure a subject's performance depends on making certain additional assumptions. Different assumptions lead to different optimal strategies. For instance, the goal of maximizing the expected time until some attacker successfully penetrates the defense would lead to different strategies, in general, than minimizing the expected number (over all the waves) of attackers to survive. Assuming the latter is the desired goal, and making some other assumptions consistent both with the design of the DTDM program and with frequently encountered real-life situations, it can be shown that always having the same number of defenders as attackers in every battle is an optimal or near-optimal strategy. (The approximate equality of total numbers of defenders and attackers is used in deriving this result.) To implement this strategy initially might well involve sending slightly more defenders to Sectors 1 and 2 than the respective "best estimates" of the attackers expected in the next wave. When (during the next wave) better intelligence is available about the actual number of attackers, having extra defenders on hand will be useful if the attackers are now thought to be more numerous than was previously thought; moreover, a slight surplus of defenders can probably be used against the following wave of attackers, should the initial intelligence estimates be revised downwards, with correspondingly fewer reinforcements being required in subsequent waves.

The numbers of aircraft that the subject actually sent to Sectors 1 and 2 seem consistent with the foregoing strategy.

The times that the subject restocked Sectors 1 and 2 are also noted. These times are of interest for several reasons. By restocking, the subject can control (within certain limits) the numbers of defenders on hand in Sectors 1 and 2 at the start of the next wave. He uses the "Performance" display (to be discussed below), together with his memory of how many defenders were restocked in each Sector in each of the preceding two waves, to determine how many defenders are currently on hand. (He needs to consider which waves the reinforcements were sent out in because this information determines which of the currently available aircraft will be "sent home for refueling" at the end of one wave, and hence unavailable during the following wave, even if they are not sent

against the attackers during the one wave.) He may use SRI (if it is available) to give a more accurate estimate of defenders used during the current wave than can be had from applying his recollection of the LRI for the preceding wave. Or, if he "takes command" of Sector 1 and/or 2, he can determine exactly how many defenders from the relevant sectors are expended during the current wave, because he can issue the order causing them to be sent out. Taken in conjunction with their other actions, the times at which the subjects send out reinforcements may help infer their game-playing sophistication and strategies. The times might also, under some circumstances, indicate the subjects' level of stress.

Here is a recapitulation of the output discussed so far:

```
Thu Oct  2 21:19:59 EDT 1986;  Scenario 1.4;  Data     01;  Group    03

WAVE 1: (TIME 0 THROUGH 59)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI
 SECTOR 0       140
 SECTOR 1   0+ 0= 0   0 0
 SECTOR 2   0+ 0= 0   0 0
LRI CONSULTED  FROM   4 THROUGH  10; FROM  58 THROUGH  83
            LRI
 SECTOR 1   7 3
 SECTOR 2   5 0
PERFORMANCE NOT CONSULTED
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT     0 TO
  15      6        1
  16      4        2
```

4.0 DISCUSSION OF WAVE 2

The first few lines of output for Wave 2 are as follows:

```
WAVE 2: (TIME 60 THROUGH 119)
STATUS AT BEGINNING OF WAVE:
             A/C AVAIL   SRI   ACCEPTABLE   RATING
 SECTOR 0        130              RANGE
 SECTOR 1     0+ 6= 6    9 5   2 THRU  8    CHECK
 SECTOR 2     0+ 4= 4    0 1   0 THRU  6    CHECK
```

The six reinforcements sent to Sector 1 during Wave 1 have arrived, as have the four reinforcements sent to Sector 2. These ten defenders have been subtracted from the stock at Sector 0, leaving a remainder of 130.

Two columns have been added at the far right of the "status" table. These columns show the "acceptable range" of defending aircraft to have on hand in Sectors 1 and 2, and a rating for the performance of the subject for his allocations to these sectors during the preceding wave. The "acceptable range" shown in Wave i (here, Wave 2) is based on the LRI during Wave (i-1) (here, Wave 1). For either sector, the range is defined to be from one less than the minimum LRI prediction for that sector (or from 0, if the minimum LRI prediction for the sector is itself 0), to one plus the maximum LRI prediction for that sector. The LRI predictions for Wave 1 were

```
             LRI
 SECTOR 1    7 3
 SECTOR 2    5 0
```

and so the "acceptable range" is as shown above. The subject's performance in allocation during the preceding wave is rated "CHECK" if the number of defending aircraft available in a given sector lies within the "acceptable range," "PLUS" if the number of defenders exceeds the "acceptable range," and "MINUS" if it is less than the "acceptable range." A more precise measure of the subject's performance might be based on comparison of aircraft available with the "best estimate" of aircraft required to meet the present incoming threat; the latter "best estimate" would be based, at least in part, on LRI "best estimates" (made during the last wave) of incoming threats during this wave and on defenders expended or "sent home for refueling" during the last wave.

The pair of SRI sensors predicts 9 and 5 attackers, respectively, headed towards Sector 1, and 0

and 1 attackers, respectively, headed towards Sector 2. The subject was instructed to weight information from each of these sensors equally, and so the "best estimates" of numbers of attackers might be 7 for Sector 1 and 0, .5, or 1 for Sector 2.

Results of consulting the LRI are as follows:

```
LRI CONSULTED  FROM  58 THROUGH  83
             LRI
 SECTOR 1    0 6
 SECTOR 2    9 4
```

Note that the time (58 through 83) of consulting the LRI shown here is the same as the second time period shown in the discussion of Wave 1, but that the content of the display is different. The reason is that the LRI was visible for 2 seconds during Wave 1 and for 24 seconds during Wave 2; during each wave the appropriate information is shown, although (like the output studied here) the content of the display changes when the wave changes. (Similar remarks apply to the "Performance," the contents of which likewise change when the wave changes.) "Best estimates" of the number of Wave-3 attackers are 3 and 6, 6.5, or 7 for Sectors 1 and 2, respectively.

The "Performance" display was consulted for two seconds during the present wave:

```
PERFORMANCE CONSULTED  FROM  118 THROUGH  129
        :..............SECTOR1...............:..............SECTOR2............... :
        : AD   : FIGHTERS : .......ENEMY....... :  AD : FIGHTERS :.......ENEMY....... :
        : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL:
WAVE 1 :  AD :      0     :    0       0     0   : AD :      0     :    0      0      0  :
```

The contents are predictably uninteresting, since there was no fighting during Wave 1. Perhaps the subject is simply getting ready a bit ahead of time to see the outcome of the Wave-2 combats, which become visible at time 120. He would need this information to help determine how many reinforcements to allocate during Wave 3.

The final output for Wave 2 is:

```
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT    NO. A/C   FROM
 TIME    SENT     0 TO
  87      6         1
  87      6         2
```

5.0 DISCUSSION OF WAVE 3

The output for the beginning of Wave 3 is:

```
WAVE 3: (TIME 120 THROUGH 179)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0       118          RANGE
 SECTOR 1    0+ 6= 6   0 2   0 THRU  7   CHECK
 SECTOR 2    3+ 6= 9   9 3   3 THRU 10   CHECK
LRI CONSULTED  FROM  133 THROUGH  153
             LRI
 SECTOR 1    9 5
 SECTOR 2    2 1
PERFORMANCE CONSULTED  FROM  118 THROUGH  129; FROM  165 THROUGH  194
       : ..............SECTOR1.............. : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 2 :  AD :     6    :    2      4     6   :  AD :     1    :    0      1     1   :
WAVE 1 :  AD :     0    :    0      0     0   :  AD :     0    :    0      0     0   :
```

Attrition took place for the first time during Wave 2 and is reflected in the performance scores that become available during Wave 3. The table above shows that six enemies attacked Sector 1, and 1 attacked sector 2, during Wave 2. All six of the defending fighters available in Sector 1 were sent against the enemy, as was one of the four fighters available in Sector 2. Note that these assignments, though made by the DTDM program rather than by the subject, were consistent with the "one-on-one" defense philosophy discussed previously.

It is time to discuss how the DTDM program computes attrition. The computation is done by "table lookup," using the table reproduced below:

	Number of Attackers	0	1	2	3	4	5	6	7	8	9
	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0
N	2	0	1	1	1	1	1	1	1	1	1
u	3	0	1	1	1	1	1	1	1	1	1
m	4	0	1	1	1	2	2	2	2	2	2
b	5	0	1	2	2	2	2	2	2	2	2
e	6	0	1	2	2	2	2	2	2	2	2
r	7	0	1	2	2	2	2	3	3	3	3
	8	0	1	2	2	3	3	3	3	3	3
o	9	0	1	2	3	3	3	3	3	3	4
f	10	0	1	2	3	3	3	3	4	4	4
	11	0	1	2	3	3	3	4	4	4	4
D	12	0	1	2	3	3	4	4	4	4	4
e	13	0	1	2	3	4	4	4	4	4	5
f	14	0	1	2	3	4	4	4	4	5	5
e	15	0	1	2	3	4	4	5	5	5	5
n	16	0	1	2	3	4	4	5	5	5	5
d	17	0	1	2	3	4	5	5	5	5	6
e	18	0	1	2	3	4	5	5	5	6	6
r	19	0	1	2	3	4	5	5	6	6	6
s	20	0	1	2	3	4	5	5	6	6	6
	21	0	1	2	3	4	5	6	6	6	6
	22	0	1	2	3	4	5	6	6	7	7
	23	0	1	2	3	4	5	6	6	7	7
	24	0	1	2	3	4	5	6	6	7	7
	25	0	1	2	3	4	5	6	7	7	7
	26	0	1	2	3	4	5	6	7	7	8
	27	0	1	2	3	4	5	6	7	7	8
	28	0	1	2	3	4	5	6	7	7	8
	29	0	1	2	3	4	5	6	7	8	8

The table shown corresponds to a ".4" level of attrition; a similarly formatted table corresponding to a ".8" level of attrition is used with some of the other scenarios. Attrition level is one of the variables manipulated in the overall experiment, although for any given subject the attrition level remains constant throughout. To find the number of enemy killed when 6 defenders combat 6 attackers, look at the entry in the row headed "6" and the column headed "6." It is "2." Similarly, 0 enemies are killed in combat between 1 defender and 1 attacker. These numbers agree with the results shown in the Performance reproduced previously.

The "table-lookup" method of computing attrition used by the DTDM program always yields the same attrition for a given number of defenders combating a given number of attackers. Although

this methodology yields results different from what would be obtained in most real-world situations, where some random variation would be expected, it might be argued that the introduction of such random variation into the overall experiment--where "attrition rate" is one of the manipulated experimental variables--would be a source of undesired variation in the experimental results.

The actual numbers appearing in the table are close to the expected attrition rates (rounded to the nearest integer) that may be calculated under suitable assumptions--involving probabilistic independence and a notion of optimal strategy based, in part, on considerations discussed above. The tabulated values are a nondecreasing function of the number of defenders, when the number of attackers is held fixed; the values are a nondecreasing function of the number of attackers, when the number of defenders is held fixed. They are (quite reasonably) zero when the number of attackers or the number of defenders is zero. In the present case they are also zero when the number of defenders is one: a result presumably deriving from the deterministic use of expected values rounded to the nearest integer, rather than the probabilistic use of random numbers based on an underlying probability distribution. In consequence, the number of attackers killed will always be zero when the number of defenders is just one, a result borne out (in Sector 2) in the Wave-3 example under present discussion.

If the subject could see the attrition table and understand the use to which it is put, he would never have any rational positive incentive for sending just one defender against an incoming wave of attackers in either Sector 1 or Sector 2. Usually it will be better, and never will it be worse, to assign either 0 or 2 defenders in such situations. Inspection of the attrition table suggests many similar observations. Over a sufficiently long sequence of waves, a subject might actually infer empirically some of this behavior of the DTDM program. That the behavior is in a sense irrelevant to the intended purpose of DTDM might even make the behavior undesirable if, for instance, starting to observe or analyze the behavior becomes a distraction for some of the subjects. Note that the behavior is observable (in the "Performance" display) regardless of whether or not the subject personally (through "taking command") chooses how many defenders to send against the enemy.

The remaining output for Wave 3 is as follows:

```
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT    NO. A/C  FROM
 TIME    SENT    0 TO
 157      4       1
 158      2       2
```

6.0 DISCUSSION OF WAVE 4

The output for Wave 4 is as follows:

```
WAVE 4: (TIME 180 THROUGH 239)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0       112          RANGE
 SECTOR 1    5+ 4= 9   7 4   4 THRU 10   CHECK
 SECTOR 2    3+ 2= 5   0 6   0 THRU  3   PLUS
LRI CONSULTED  FROM  198 THROUGH  205
            LRI
 SECTOR 1   5 8
 SECTOR 2   2 0
PERFORMANCE CONSULTED  FROM  165 THROUGH  194; FROM  232 THROUGH  250
       : ..............SECTOR1.............. : .............SECTOR2............... :
       : AD   : FIGHTERS : .......ENEMY....... : AD   : FIGHTERS : .......ENEMY....... :
       : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD  : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 3 :  AD  :     1    :   0      1      1   :  AD  :    6     :   2      5      7   :
WAVE 2 :  AD  :     6    :   2      4      6   :  AD  :    1     :   0      1      1   :
WAVE 1 :  AD  :     0    :   0      0      0   :  AD  :    0     :   0      0      0   :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC TOOK COMMAND OF SECTOR 2  FROM  216 THROUGH  221
            SRI
 SECTOR 2   0 6
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 210      6       1
 211      2       2
```

Wave 4 is the first one in which the present subject "takes command" (of Sector 2, in this case). For some subjects (those for whom the "Data 00" phrase applies, as discussed above) the SRI becomes visible only for Sectors that they "take command" of. The contents of the SRI display that such subjects then see is shown in the data-reduction program output as in the excerpt above (5th and 6th lines from the bottom of the excerpt). The subject's decision on how many defenders to send against the attackers in Section 2 will be shown in the "Performance" display for the next wave.

7.0 DISCUSSION OF WAVE 5

The output for Wave 5 is as follows:

```
WAVE 5: (TIME 240 THROUGH 299)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0      104           RANGE
 SECTOR 1    3+ 6= 9   4 8   4 THRU  9   CHECK
 SECTOR 2    0+ 2= 2   1 3   0 THRU  3   CHECK
LRI CONSULTED  FROM  257 THROUGH  267
            LRI
 SECTOR 1    2 7
 SECTOR 2    4 8
PERFORMANCE CONSULTED  FROM  232 THROUGH  250; FROM  289 THROUGH  313
       : ..............SECTOR1.............. : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 4 :  AD :     6    :   2      4     6    :  MD :     5    :   2      1     3    :
WAVE 3 :  AD :     1    :   0      1     1    :  AD :     6    :   2      5     7    :
WAVE 2 :  AD :     6    :   2      4     6    :  AD :     1    :   0      1     1    :
BGC TOOK COMMAND OF SECTOR 1  FROM  277 THROUGH  281
            SRI
 SECTOR 1    4 8
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 271     6       1
 272     6       2
```

The "Performance" table shows that the subject chose to send 5 defending fighters against the incoming wave of (as it turned out) 3 attackers. The result was 2 attackers killed and 1 missed, as can be seen by consulting the attrition table shown above.

The "Performance" table column headed "AD/MD" tells whether the assignment of fighters against the enemy was made by the subject or not. In the former case "MD" (for "Manual Defense") appears in this column; otherwise "AD" (for "Automatic Defense") appears.

8.0 DISCUSSION OF WAVES 6 AND 7

Output for these waves is as follows:

```
WAVE 6: (TIME 300 THROUGH 359)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        92          RANGE
 SECTOR 1   1+ 6= 7   1 7   1 THRU  8   CHECK
 SECTOR 2   0+ 6= 6   7 9   3 THRU  9   CHECK
LRI CONSULTED  FROM  324 THROUGH  331
            LRI
 SECTOR 1   5 0
 SECTOR 2   9 3
PERFORMANCE CONSULTED  FROM  289 THROUGH  313; FROM  356 THROUGH  373
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 5 :  MD :      8   :    3      4      7  :  AD :     2    :    1      1      2  :
WAVE 4 :  AD :      6   :    2      4      6  :  MD :     5    :    2      1      3  :
WAVE 3 :  AD :      1   :    0      1      1  :  AD :     6    :    2      5      7  :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC TOOK COMMAND OF SECTOR 2  FROM  317 THROUGH  321
            SRI
 SECTOR 2   7 9
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 336     4       1
 338     8       2
WAVE 7: (TIME 360 THROUGH 419)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        80          RANGE
 SECTOR 1   3+ 4= 7   4 0   0 THRU  6   PLUS
 SECTOR 2   0+ 8= 8   9 2   2 THRU 10   CHECK
LRI CONSULTED  FROM  376 THROUGH  391
            LRI
 SECTOR 1   2 6
 SECTOR 2   8 9
PERFORMANCE CONSULTED  FROM  356 THROUGH  373; FROM  40[illegible] THROUGH  431
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 6 :  AD :      4   :    1      2      3  :  MD :     6    :    2      6      8  :
WAVE 5 :  MD :      8   :    3      4      7  :  AD :     2    :    1      1      2  :
WAVE 4 :  AD :      6   :    2      4      6  :  MD :     5    :    2      1      3  :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
```

```
RESTOCKING AIRCRAFT:
  AT    NO. A/C   FROM
 TIME    SENT     0 TO
 394      4         1
 39[illegible]      8         2
DEFENDERS SENT HOME FOR REFUELING
 TIME   SECTOR  NO. A/C
 4[illegible]       1         1
```

Wave 7 provides the first instance so far in which defenders are sent home for refueling. In the context of the present scenario this is sometimes an indication of less than optimal performance. The attrition table shows that sending additional defenders against an incoming wave of attackers will not decrease, and may in fact increase, the number of attackers killed. In the current case one defender is sent home for refueling from Sector 1. The status at the beginning of Wave 7 shows a total of seven defenders currently available in Sector 1. Of these seven, three will be "sent home for refueling" at the end of Wave 7 unless they are sent against the attackers during the wave. The "Performance" table in the Wave-8 output will show that in fact just two defenders are sent against an incoming wave of what turns out to be just two attackers during Wave 7. The resulting attrition consists of just one enemy attacker killed. In fact, using the present attrition table, only if five of the available Sector 1 defenders were sent against the two attackers would the attacker attrition go from one to two.

Arguably, in many real-life situations sending an additional defender against a wave of attackers would always increase the expected attrition to attackers. Clearly this is not always the case in DTDM.

9.0 DISCUSSION OF WAVES 8 THROUGH 15

The output for Waves 8 through 15 is as follows:

```
WAVE 8: (TIME 420 THROUGH 479)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        68           RANGE
 SECTOR 1    4+ 4= 8    3 7   1 THRU  7   PLUS
 SECTOR 2    2+ 8=10    8 9   7 THRU 10   CHECK
LRI CONSULTED  FROM  434 THROUGH  450; FROM  471 THROUGH  476
             LRI
 SECTOR 1    1 8
 SECTOR 2    8 1
PERFORMANCE CONSULTED  FROM  403 THROUGH  431
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 7 :  AD :     2    :    1      1     2   :  AD :     6    :    2      3     5   :
WAVE 6 :  AD :     4    :    1      2     3   :  MD :     6    :    2      6     8   :
WAVE 5 :  MD :     8    :    3      4     7   :  AD :     2    :    1      1     2   :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC TOOK COMMAND OF SECTOR 2  FROM  460 THROUGH  464
             SRI
 SECTOR 2    8 9
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 454      5      1
 454      5      2
```

```
WAVE 9: (TIME 480 THROUGH 539)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        58          RANGE
 SECTOR 1   3+ 5= 8   2 8   0 THRU  9   CHECK
 SECTOR 2   1+ 5= 6   8 2   0 THRU  9   CHECK
LRI CONSULTED  FROM  499 THROUGH  516
            LRI
 SECTOR 1   9 8
 SECTOR 2   6 2
PERFORMANCE CONSULTED  FROM  488 THROUGH  496; FROM  539 THROUGH  549
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 8 :  AD :     5    :    2      2     4   :  MD :     9    :    3      5     8   :
WAVE 7 :  AD :     2    :    1      1     2   :  AD :     6    :    2      3     5   :
WAVE 6 :  AD :     4    :    1      2     3   :  MD :     6    :    2      6     8   :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 521      6       1
 521      6       2

WAVE 10: (TIME 540 THROUGH 599)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        46          RANGE
 SECTOR 1   3+ 6= 9   9 8   7 THRU 10   CHECK
 SECTOR 2   1+ 6= 7   7 3   1 THRU  7   CHECK
LRI CONSULTED  FROM  560 THROUGH  573
            LRI
 SECTOR 1   3 9
 SECTOR 2   0 5
PERFORMANCE CONSULTED  FROM  539 THROUGH  549; FROM  598 THROUGH  609
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE 9 :  AD :     5    :    2      4     6   :  AD :     5    :    2      4     6   :
WAVE 8 :  AD :     5    :    2      2     4   :  MD :     9    :    3      5     8   :
WAVE 7 :  AD :     2    :    1      1     2   :  AD :     6    :    2      3     5   :
BGC TOOK COMMAND OF SECTOR 1  FROM  [illegible] THROUGH  [illegible]
            SRI
 SECTOR 1   9 8
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 576      7       1
 5[illegible]      3       2
```

```
WAVE 11: (TIME 600 THROUGH 659)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0       36           RANGE
 SECTOR 1   0+ 7= 7   2 9   2 THRU 10   CHECK
 SECTOR 2   2+ 3= 5   0 4   0 THRU  6   CHECK
LRI CONSULTED  FROM  614 THROUGH  628
            LRI
 SECTOR 1   8 4
 SECTOR 2   7 2
PERFORMANCE CONSULTED  FROM  598 THROUGH  609; FROM  646 THROUGH  670
        ..............SECTOR1............... : ..............SECTOR2............... :
       : AD   : FIGHTERS : .......ENEMY....... : AD   : FIGHTERS : .......ENEMY....... :
       : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD  : VS.ENEMY : KILLED MISSED TOTAL :
WAVE10 :  MD  :     9    :    3      5      8  :  AD  :     5    :    2      2      4  :
WAVE 9 :  AD  :     5    :    2      4      6  :  AD  :     5    :    2      4      6  :
WAVE 8 :  AD  :     5    :    2      2      4  :  MD  :     9    :    3      5      8  :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 634     7        1
 635     5        2

WAVE 12: (TIME 660 THROUGH 719)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0       24           RANGE
 SECTOR 1   1+ 7= 8   9 7   3 THRU  9   CHECK
 SECTOR 2   3+ 5= 8   7 1   1 THRU  8   CHECK
LRI CONSULTED  FROM  673 THROUGH  688; FROM  703 THROUGH  705
            LRI
 SECTOR 1   0 2
 SECTOR 2   8 5
PERFORMANCE CONSULTED  FROM  646 THROUGH  670; FROM  708 THROUGH  732
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD   : FIGHTERS : .......ENEMY....... : AD   : FIGHTERS : .......ENEMY....... :
       : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD  : VS.ENEMY : KILLED MISSED TOTAL :
WAVE11 :  AD  :     6    :    2      3      5  :  AD  :     2    :    1      1      2  :
WAVE10 :  MD  :     9    :    3      5      8  :  AD  :     5    :    2      2      4  :
WAVE 9 :  AD  :     5    :    2      4      6  :  AD  :     5    :    2      4      6  :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
 694     1        1
 696     6        2
```

```
WAVE 13: (TIME 720 THROUGH 779)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        17           RANGE
 SECTOR 1   0+ 1= 1   3 1   0 THRU  3   CHECK
 SECTOR 2   4+ 6=10   8 4   4 THRU  9   PLUS
LRI CONSULTED  FROM  735 THROUGH  749
            LRI
 SECTOR 1   1 2
 SECTOR 2   5 9
PERFORMANCE CONSULTED  FROM  708 THROUGH  732; FROM  766 THROUGH  796
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD   : FIGHTERS : .......ENEMY....... : AD   : FIGHTERS : .......ENEMY....... :
       : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD  : VS.ENEMY : KILLED MISSED TOTAL :
WAVE12 :  AD :      8    :    3      5     8   :  AD :     4    :    1      2     3   :
WAVE11 :  AD :      6    :    2      3     5   :  AD :     2    :    1      1     2   :
WAVE10 :  MD :      9    :    3      5     8   :  AD :     5    :    2      2     4   :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT     0 TO
 754      2        1
 755      5        2

WAVE 14: (TIME 780 THROUGH 839)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0        10           RANGE
 SECTOR 1   0+ 2= 2   6 0   0 THRU  3   CHECK
 SECTOR 2   4+ 5= 9   4 7   4 THRU 10   CHECK
LRI CONSULTED  FROM  799 THROUGH  817
            LRI
 SECTOR 1   4 9
 SECTOR 2   6 0
PERFORMANCE CONSULTED  FROM  766 THROUGH  796
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD   : FIGHTERS : .......ENEMY....... : AD   : FIGHTERS : .......ENEMY....... :
       : /MD  : VS.ENEMY : KILLED MISSED TOTAL : /MD  : VS.ENEMY : KILLED MISSED TOTAL :
WAVE13 :  AD :      1    :    0      2     2   :  AD :     6    :    2      5     7   :
WAVE12 :  AD :      8    :    3      5     8   :  AD :     4    :    1      2     3   :
WAVE11 :  AD :      6    :    2      3     5   :  AD :     2    :    1      1     2   :
BGC DID NOT TAKE COMMAND OF SECTOR 1
BGC TOOK COMMAND OF SECTOR 2  FROM  830 THROUGH  835
            SRI
 SECTOR 2   4 7
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT     0 TO
 824      6        1
          0
```

```
WAVE 15: (TIME 840 THROUGH 899)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0         4          RANGE
 SECTOR 1    0+ 6= 6   3 9   3 THRU 10   CHECK
 SECTOR 2    4+ 0= 4   2 0   0 THRU  7   CHECK
LRI CONSULTED  FROM  859 THROUGH  867; FROM  898 THROUGH  903
            LRI
 SECTOR 1   0 5
 SECTOR 2   3 7
PERFORMANCE CONSULTED  FROM  846 THROUGH  856
       : ..............SECTOR1............... : ..............SECTOR2............... :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : ... ...ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE14 :  AD :     2    :    1      2     3   :  MD :     5    :    0      6     6   :
WAVE13 :  AD :     1    :    0      2     2   :  AD :     6    :    2      5     7   :
WAVE12 :  AD :     8    :    3      5     8   :  AD :     4    :    1      2     3   :
BGC TOOK COMMAND OF SECTOR 1  FROM  880 THROUGH  885
            SRI
 SECTOR 1   3 9
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT     0 TO
 876      1        1
 875      3        2
DEFENDERS SENT HOME FOR REFUELING
 TIME  SECTOR  NO. A/C
 900      2        3
```

The "Performance" table output for Wave 15 shows that, during Wave 14, the subject sent five defenders against six attackers in Sector 1, without any attrition to the attackers. How could this be? There is in fact a time limit (about 45 or 50 seconds into the relevant wave) imposed by the DTDM program on how late the subject may send defenders against the attackers when he has "taken command" of Sector 1 or 2. When this time limit is exceeded no attackers will be killed, even though the appropriate number of defending fighters is shown as having been sent. The subjects were informed of the existence of this time limit. This seeming anomaly in the output data came to light only after the data-reduction program was written, and in fact as a result of writing the data-reduction program. If time were available it would be desirable to find a way to rewrite the data-reduction program so as to flag such occurrences of the subject exceeding the time limit; fortunately, the number of such occurrences is probably small. On the other hand, the occurrences are of interest, if only because they provide another indication of the subject behaving under stress.

10.0 DISCUSSION OF WAVE 16

The output for Wave 16 is as follows:

```
WAVE 16: (TIME 900 THROUGH 959)
STATUS AT BEGINNING OF WAVE:
           A/C AVAIL  SRI  ACCEPTABLE  RATING
 SECTOR 0          0          RANGE
 SECTOR 1   1+ 1= 2   1 0   0 THRU  6   CHECK
 SECTOR 2   0+ 3= 3   5 9   2 THRU  8   CHECK
LRI CONSULTED  FROM  898 THROUGH  903; FROM  909 THROUGH  917; FROM  936 THROUGH  942
            LRI
 SECTOR 1   7 2
 SECTOR 2   8 4
PERFORMANCE NOT CONSULTED
       : ..............SECTOR1.............. : ..............SECTOR2.............. :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE15 :  MD :    5     :   2      5     7    :  AD :    1     :   0      1     1    :
WAVE14 :  AD :    2     :   1      2     3    :  MD :    5     :   0      6     6    :
WAVE13 :  AD :    1     :   0      2     2    :  AD :    6     :   2      5     7    :
BGC TOOK COMMAND OF SECTOR 1  FROM  919 THROUGH  921
            SRI
 SECTOR 1   1 0
BGC DID NOT TAKE COMMAND OF SECTOR 2
RESTOCKING AIRCRAFT:
  AT   NO. A/C  FROM
 TIME   SENT    0 TO
          0       1
          0       2

PERFORMANCE ON LAST WAVE
       : ..............SECTOR1.............. : ..............SECTOR2.............. :
       : AD  : FIGHTERS : .......ENEMY....... : AD  : FIGHTERS : .......ENEMY....... :
       : /MD : VS.ENEMY : KILLED MISSED TOTAL : /MD : VS.ENEMY : KILLED MISSED TOTAL :
WAVE16 :  MD :    1     :   0      1     1    :  AD :    3     :   1      5     6    :
WAVE15 :  MD :    5     :   2      5     7    :  AD :    1     :   0      1     1    :
WAVE14 :  AD :    2     :   1      2     3    :  MD :    5     :   0      6     6    :

STATUS AT END OF SCENARIO:
           A/C AVAIL  ACCEPTABLE  RATING
 SECTOR 0          0     RANGE
 SECTOR 1   1+ 0= 1   1 THRU  8   CHECK
 SECTOR 2   0+ 0= 0   3 THRU  9   MINUS
```

During Wave 16 LRI reports are available predicting enemy attackers arriving on a following wave. The following wave is actually not part of the scenario; nevertheless, the subject is responsible for restocking aircraft to Sectors 1 and 2 during Wave 16. The results of any combat that take place

during Wave 16, together with a rating of the subject's restocking during Wave 16, are appended to the data-reduction program's output, as shown above.

11.0 SUMMARY TABLES

Also appended to the output from the data-reduction program are a number of summary tables and statistics.

First, the numbers of "CHECK"s, "PLUS"es, and "MINUS"es are tallied:

```
SUMMARY:
SUBJECT PERFORMANCE: 27 CHECKS; 1 MINUS; 4 PLUSES
```

Next, statistics summarizing the number of times the subject "took command":

```
NUMBER OF TIMES SUBJECT TOOK CONTROL:
 WAVE    SECTOR 1   SECTOR 2   BOTH SECTORS
  1         0          0           0
  2         0          0           0
  3         0          0           0
  4         0          1           1
  5         1          0           1
  6         0          1           1
  7         0          0           0
  8         0          1           1
  9         0          0           0
 10         1          0           1
 11         0          0           0
 12         0          0           0
 13         0          0           0
 14         0          1           1
 15         1          0           1
 16         1          0           1
 TOTAL      4          4           8
 MEAN       0.25       0.25        0.50
```

The subject's history of checking the long-range intelligence is shown:

```
CHECKING LONG RANGE INTELLIGENCE DATA:
 SUBJECT CHECKED LRI 2 TIMES DURING WAVE  1
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  2
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  3
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  4
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  5
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  6
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  7
 SUBJECT CHECKED LRI 2 TIMES DURING WAVE  8
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE  9
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE 10
 SUBJECT CHECKED LRI 1 TIME  DURING WAVE 11
 SUBJECT CHECKED LRI 2 TIMES DURING WAVE 12
```

```
SUBJECT CHECKED LRI 1 TIME  DURING WAVE 13
SUBJECT CHECKED LRI 1 TIME  DURING WAVE 14
SUBJECT CHECKED LRI 2 TIMES DURING WAVE 15
SUBJECT CHECKED LRI 3 TIMES DURING WAVE 16
TOTAL              22       OVER ALL WAVES
MEAN                1.375   OVER ALL WAVES
```

Checking the "Performance" display:

```
CHECKING PERFORMANCE DATA:
 SUBJECT CHECKED PERFORMANCE DATA 0 TIMES DURING WAVE  1
 SUBJECT CHECKED PERFORMANCE DATA 1 TIME  DURING WAVE  2
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  3
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  4
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  5
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  6
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  7
 SUBJECT CHECKED PERFORMANCE DATA 1 TIME  DURING WAVE  8
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE  9
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE 10
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE 11
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE 12
 SUBJECT CHECKED PERFORMANCE DATA 2 TIMES DURING WAVE 13
 SUBJECT CHECKED PERFORMANCE DATA 1 TIME  DURING WAVE 14
 SUBJECT CHECKED PERFORMANCE DATA 1 TIME  DURING WAVE 15
 SUBJECT CHECKED PERFORMANCE DATA 0 TIMES DURING WAVE 16
 TOTAL                           24       OVER ALL WAVES
 MEAN                             1.500   OVER ALL WAVES
```

How long it took the subject to send out reinforcements to Sectors 1 and 2 may be an indicator of subject strategy or stress, as discussed above:

TIME INTO WAVE WHEN SUBJECT SENT OUT REINFORCEMENTS

WAVE	TO SECTOR 1	TO SECTOR 2
1	15	16
2	27	27
3	37	38
4	30	31
5	31	32
6	36	38
7	34	35
8	34	34
9	41	41
10	36	37
11	34	35
12	34	36
13	34	35
14	44	***
15	36	35
16	***	***

(NOTE: "***" INDICATES NO REINFORCEMENTS SENT TO THIS SECTOR DURING THIS WAVE)

Moreover, failing to send out any reinforcements to some sector during a wave may be an indicator of stress or of poor performance, although the specifics of the pertinent situation must be consulted in each case.

Finally, aircraft sent home for refueling are typically an indication of stress or of poor performance, as discussed above, although again the specifics of the pertinent situation should be consulted before passing judgment.

A/C SENT HOME FOR REFUELING:

WAVE	FROM SECTOR 1	FROM SECTOR 2
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	1	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	3
16	0	0

APPENDIX D

DISTRIBUTED TACTICAL DECISION MAKING GAME PROBLEMS

INTRODUCTION

The study in which you will participate is designed to examine how individuals make decisions when only limited information is available. Your task will be to play the role of a spaceship officer who must work as a member of a team to defend the headquarters from an alien attack. During the game you will be asked to make a variety of decisions, and will then be given the opportunity to think about and explain your choices. This study is designed to determine the kinds of decision rules people use most often. You may be asked to answer a brief questionnaire at the end of the study which is also concerned with different decision-making rules people prefer. The game is easy to learn and fun to play. You do not need any special knowledge or experience to participate. Everything you need to know will be taught to you.

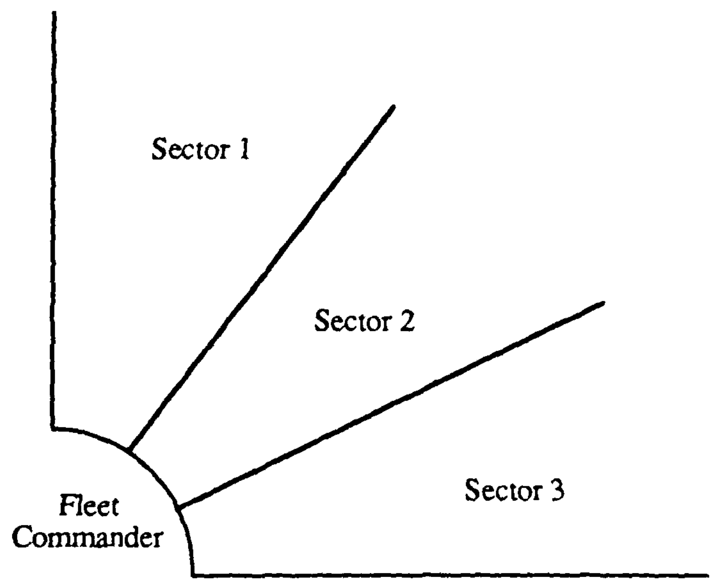
GAME BACKGROUND

The decisions you will make in this game are set in the year 2050. A conflict has arisen just outside the defense perimeter of the *Galaxy Space Station, which contains the only hospital within* thirty light years of the area. The hosptial laboratories develop vaccines to protect space colonists from the alien bacteria and diseases they encounter during their travels.

The Galaxy recently sent a ship to collect an important trace chemical from the nearby planet Vitalan, which is necessary for vaccine production. When the ship returned to the Galaxy Space Station, it was ambushed by the alien Ramdocks, who want to use the trace chemical to produce nerve gases to destroy the space colonists and repopulate the galaxy with android warriors. The Galaxy explorer ship was able to escape and return to the station. Unfortunately, the Ramdocks followed and have begun to batter the space station with waves of attacking ships piloted by warrior androids and robots. The Galaxy has called up its defense ships, and is preparing to defend the Station against any more Ramdock attacks which may be forthcoming.

In the game you will be a team member whose mission is to defend the Galaxy Space Station and its vital hospital. A team is composed of one Fleet Commander and three Sector Officers. The Fleet Commander and Sector Officers must work together to defend a ninety-degree area in outer space. Each of the Sector Officers controls a specific thirty-degree sector. The figure below shows a diagram of the positions they control.

The Sector Officer must request ships from the Fleet Commander. It is the Fleet Commander's job to send the correct number of ships based on the number requested. The Commander divides the ships according to the proportion requested by each sector. Once the ships are sent and arrive in the sector, they are under the control of the Sector Officer. Each ship is armed with two missiles. One missile is radar-controlled and 95% accurate. The other missile is heat-seeking and about 45% accurate. Ships that are launched and successfully destroy alien ships will return to Fleet Command to re-arm and refuel. Complete refueling can take several hours which means that some of these ships may not be ready for combat on the next attack. Therefore, it is important not to use ships too quickly.



GALAXY DEFENSE SPACE STATION

THE GAME

In this game you will play the role of a Sector Officer. As a Sector Officer, your goal is to work with the other Sector Officers to defend the Space Station. Every sector must cooperate for the Space Station to survive. A successful Sector Officer makes decisions that balance between two conflicting goals. On the one hand, the Officer must request enough ships to successfully meet the alien threat in his/her sector. If the Sector Officer requests too few ships, he/she will not be able to meet the threat for that sector. On the other hand, he/she must be careful not to request more than a fair share of available ships. If the Officer requests too many ships, that could use up the Fleet Command forces too fast and there would not be enough ships ready for the next wave or alien attack, or it could weaken the defense of another sector.

Each of the following game problems is completely distinct. That is, the decisions made in one scenario do not have any bearing on any scenarios that follow or precede it. Each scenario should be treated as a complete story in itself. The "story" of each game begins with a summary of events from an alien attack wave which has just ended. The report will include: (1) the share of available ships you received from Fleet Command, (2) the group's total "hit rate," and your individual Sector's "hit rate." Based on this information, you will be asked to choose what portion of the available ships you want for meeting the next alien attack wave. You will also be asked to write a brief explanation about why you made that choice.

Some decisions are easier than others to make. Think about the importance of defending your Sector, as well as the importance of not using up the available resources too rapidly. Remember that the goal is for all three Sector Officers to do their job to defend the Space Station. Often, no choice will be absolutely "right." When that happens, just pick that choice you believe is "better." Good luck, Sector Officer.

GAME PROBLEM C1.I1.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 20 % of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I1.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

CAME PROBLEM G1.I1.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I2.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I2.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I2.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I3.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I3.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I3.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I4.R1.

<u>Summary of Last Alien Attack</u>

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20%. Your individual sector achieved a hit rate of 80%.

<u>Preparing for the Next Alien Attack</u>

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G1.I4.R2.

<u>Summary of Last Alien Attack</u>

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 20% Your individual sector achieved a hit rate of 80%.

<u>Preparing for the Next Alien Attack</u>

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships [illegible] you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80% 90%

GAME PROBLEM G1.I4.R3.

<u>Summary of Last Alien Attack</u>

You are Sector Officer in charge of defending Sector 3. On the last [illegible] available Fleet Command ships. The entire group (Sectors 1, 2 and [illegible] Your individual sector achieved a hit rate of 80%

<u>Preparing for the Next Alien Attack</u>

A new enemy attack wave is [illegible] you request to defend your sector

10% 20% [illegible]

AD-A189 135 PROGRAM OF BASIC RESEARCH IN DISTRIBUTED TACTICAL DECISION MAKING(U) PAR GOVERNMENT SYSTEMS CORP NEW HARTFORD NY R J MCTEIGUE ET AL 05 AUG 87 PGSC-87-37 2/2

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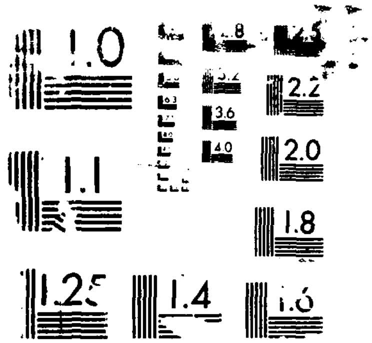
1.0
2.2
3.6
4.0
2.0
1.1
1.8
1.4

GAME PROBLEM G2.I1.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received of 20% all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I1.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I1.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I2.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40% Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I2.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I2.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I3.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received of 20% all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40% Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I3.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I3.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I4.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I4.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G2.I4.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 40%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I1.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I1.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I1.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I2.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I2.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70 ___80%___90%

GAME PROBLEM G3.I2.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I1.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I1.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I1.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 20%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I3.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60% Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I3.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I3.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I4.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I4.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1.On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G3.I4.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 60%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I2.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I2.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

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GAME PROBLEM G4.I2.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 40%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

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GAME PROBLEM G4.I3.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I3.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I3.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 1. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 60%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

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GAME PROBLEM G4.I4.R1.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 2. On the last wave of attack you received 20% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I4.R2.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 33% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

GAME PROBLEM G4.I4.R3.

Summary of Last Alien Attack

You are Sector Officer in charge of defending Sector 3. On the last wave of attack you received 50% of all available Fleet Command ships. The entire group (Sectors 1, 2, and 3) achieved a total combined hit rate of 80%. Your individual sector achieved a hit rate of 80%.

Preparing for the Next Alien Attack

A new enemy attack wave is forming outside the boundaries of each sector. What share of available ships do you request to defend your sector?

___10%___20%___30%___40%___50%___60%___70%___80%___90%

APPENDIX E

EYSENCK PERSONALITY INVENTORY

FOR EACH QUESTION, CIRCLE ONLY ONE ANSWER

1.	Do you like plenty of excitement and bustle around you?	YES	NO
2.	Have you often got a restless feeling that you want something but do not know what?	YES	NO
3.	Do you nearly always have a "ready answer" when people talk to you?	YES	NO
4.	Do you sometimes feel happy, sometimes sad, without any real reason?	YES	NO
5.	Do you usually stay in the background at parties and "get-togethers"?	YES	NO
6.	As a child did you always do as you were told immediately and without grumbling?	YES	NO
7.	Do you sometimes sulk?	YES	NO
8.	When you are drawn into a quarrel, do you prefer to "have it out" to being silent, hoping things will blow over?	YES	NO
9.	Are you moody?	YES	NO
10.	Do you like mixing with people?	YES	NO
11.	Have you often lost sleep over your worries?	YES	NO
12.	Do you sometimes get cross?	YES	NO
13.	Would you call yourself happy-go-lucky?	YES	NO
14.	Do you often make up your mind too late?	YES	NO
15.	Do you like working alone?	YES	NO
16.	Have you often felt listless and tired for no good reason?	YES	NO

17. Are you rather lively?	YES	NO
18. Do you sometimes laugh at a dirty joke?	YES	NO
19. Do you often feel "fed-up"?	YES	NO
20. Do you feel uncomfortable in anything but everyday clothes?	YES	NO
21. Does your mind often wander when you are trying to attend closely to something?	YES	NO
22. Can you put your thoughts into words quickly?	YES	NO
23. Are you often "lost in thought"?	YES	NO
24. Are you completely free from prejudices of any kind?	YES	NO
25 Do you like practical jokes?	YES	NO
26. Do you often think of your past?	YES	NO
27. Do you very much like good food?	YES	NO
28. When you get annoyed do you need someone friendly to talk to about it?	YES	NO
29. Do you mind selling things or asking people for money for some good cause?	YES	NO
30. Do you sometimes boast a little?	YES	NO
31. Are you touchy about some things?	YES	NO
32. Would you rather be at home on your own than go to a boring party?	YES	NO
33. Do you sometimes get so restless that you cannot sit long in a chair?	YES	NO
34. Do you like planning things carefully, well ahead of time?	YES	NO

35. Do you have dizzy spells? YES NO

36. Do you always answer a personal letter as soon as you can after you have read it? YES NO

37. Can you usually do things better by figuring them out alone than by talking to others about it? YES NO

38. Do you ever get short of breath without having done heavy work? YES NO

39. Are you an easy-going person, not generally bothered about having everything "just-so"? YES NO

40. Do you suffer from "nerves"? YES NO

41. Would you rather plan things than do things? YES NO

42. Do you sometimes put off until tomorrow what you ought to do today? YES NO

43. Do you get nervous in places like elevators, trains or tunnels? YES NO

44. When you make new friends, is it usually you who makes the first move, or does the inviting? YES NO

45. Do you get very bad headaches? YES NO

46. Do you generally feel that things will sort themselves out and come right in the end somehow? YES NO

47. Do you find it hard to fall asleep at bedtime? YES NO

48. Have you sometimes told lies in your life? YES NO

49. Do you sometimes say the first thing that comes into your head? YES NO

50. Do you worry too long after an embarrassing experience? YES NO

51. Do you usually keep "yo[illegible]lf to yourself" except with very close with friends? YES NO

52. Do you often get into a jam because you do things without thinking? YES NO

53. Do you like cracking jokes and telling funny stories to your friends? YES NO

54. Would you rather win than lose a game? YES NO

55. Do you often feel self-concious when you are with superiors? YES NO

56. When the odds are against you, do you still usually think it worth taking a chance? YES NO

57. Do you often get "butterflies in your stomach" before an important occasion? YES NO

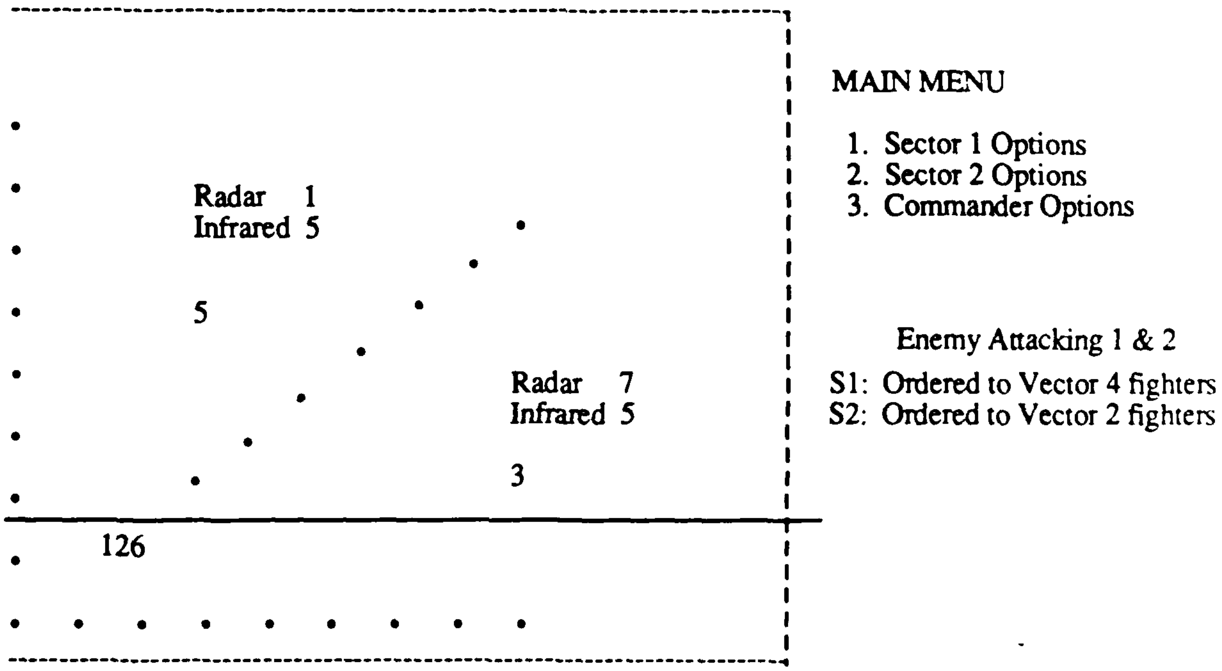
APPENDIX F

INTRODUCTION

The experiment you are participating in is designed to investigate how people make decisions in a group-oriented task. The task you and two other group members will be participating in is based on a computerized space war game. You do not need any knowledge of or experience with computers to participate. Everything you need to know will be taught to you.

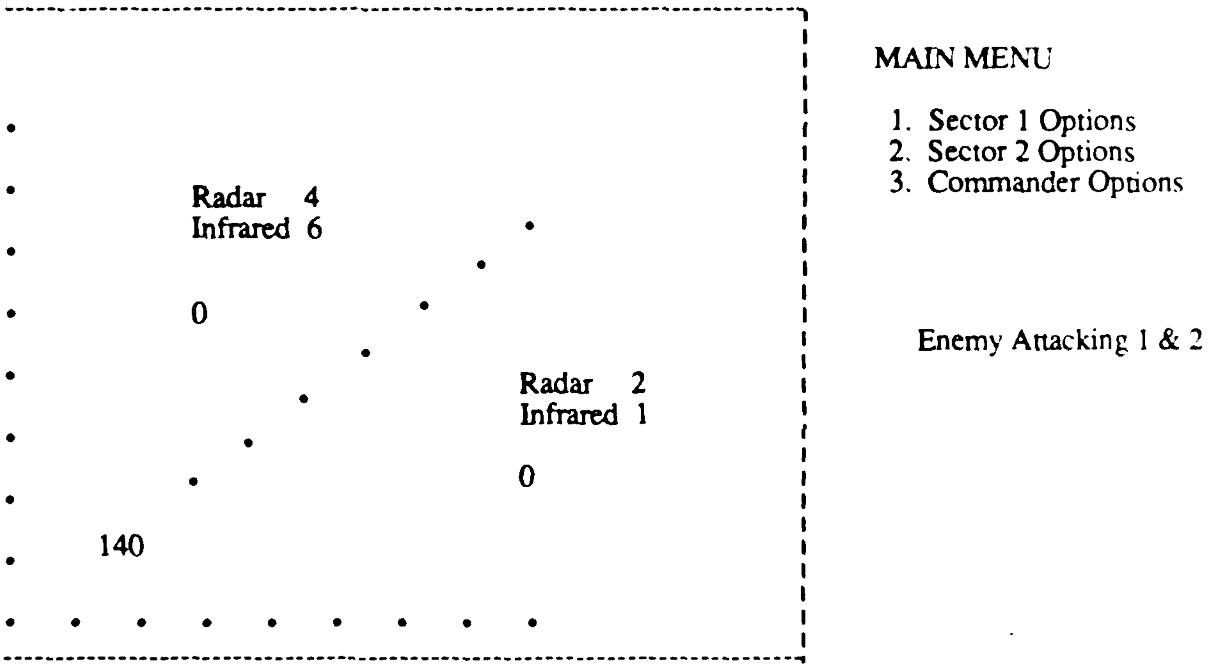
In this experiment, the three members in your group will play the role of three commanders whose mission is to defend a 90-degree area that must be defended against enemy threats attacking the Star Fleet. Sector 1 is controlled by a Star Fighter Commander as is Sector 2. You will control the Star Fleet Commander position. The figure below shows the layout of the three sector positions as they will appear on your computer terminal.

You and the other two commanders will each have a computer terminal.



STAR FIGHTERS

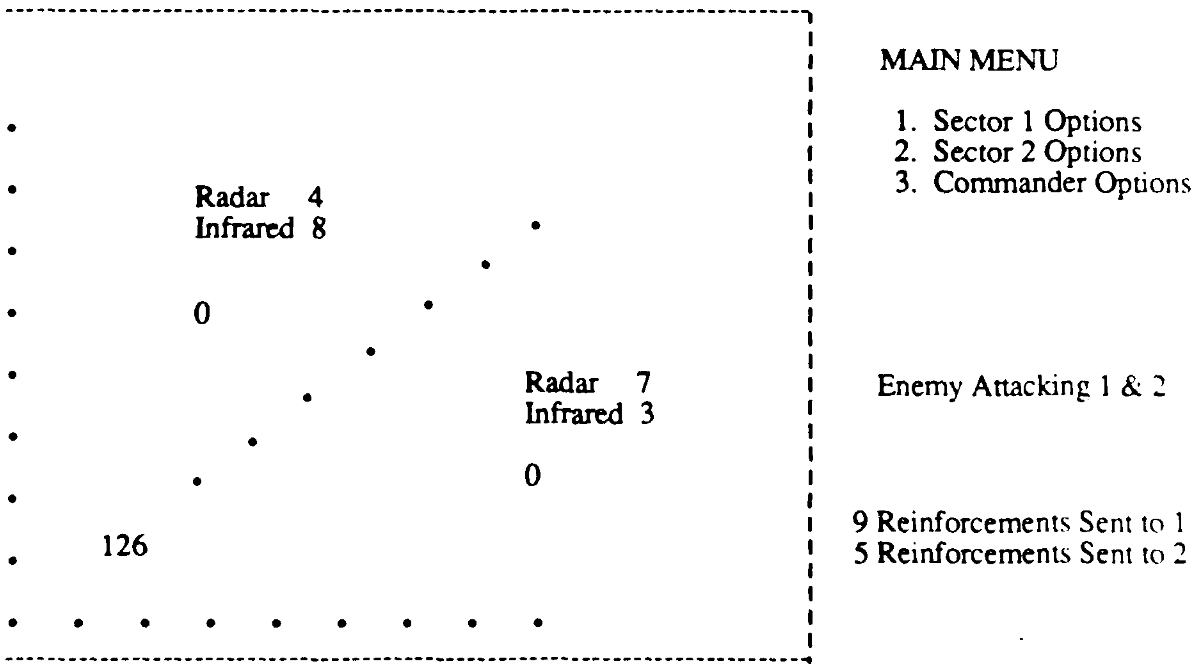
Each Star Fighter Commander will initially have control of zero (0) star fighters. Each star fighter has one missile capable of destroying one enemy threat. The figure below shows the star fighters that each commander has control of at the beginning of each mission. As shown below, the Star Fleet Commander initially has control of 140 star fighters. These fighters must be sent out to the two sectors in order for them to protect the fleet. How to send out these fighters will be explained in a moment.



ENEMY THREATS

Enemy threats will only attack in the direction of sectors 1 and 2. In each mission presented to you, there will be several waves of attack. Each wave of attack can contain from one to nine enemy threats per sector. Each wave will be represented by the Short-Range intelligence data shown at each sector. This data is not always 100% accurate since the enemy is jamming your radar and other intelligence gathering sources. Thus, neither you nor the Star Fighter Commanders will always be able to tell exactly how may threats are contained in a wave.

In addition, the Star Fleet Commander has available Long-Range Intelligence data which gives information about the next incoming wave of attack. Since this information is a long-range forecast, this data is not as accurate as the short-range intelligence data. Intelligence data will be discussed in more detail in a moment. The figure below provides an example of an incoming enemy attack.

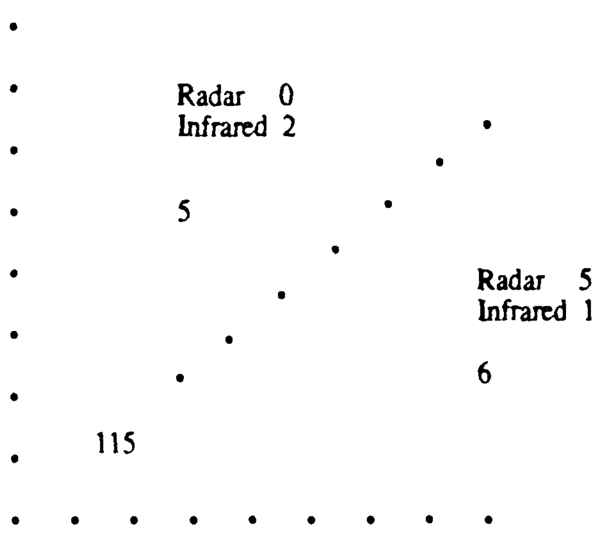


VECTORING YOUR STAR FIGHTERS AND DESTROYING ENEMY THREATS

All enemy threats will only attack in the direction of Sector 1 or Sector 2. These threats can only be destroyed before they reach the perimeter of Sectors 1 or 2. Once an enemy has entered into Sectors 1 or 2 it cannot be destroyed.

Since enemy threats will only attack the Star Fighter Commanders, the two Star Fighter Commanders in control of Sectors 1 or 2 can directly destroy enemy threats. For example, if three enemy threats were attacking Sector 1, the commander in control of Sector 1 could vector (send) his star fighters toward the enemy threats. As long as the star fighters reached the enemy threats before they entered into Sector 1, the enemy threats would be destroyed.

Under optimal conditions each star fighter can destroy one enemy threat, however, this does not always occur. The total number of incoming threats, the total number of outgoing star fighters--those sent out by the Star Fighter Commander--and the performance of your fighter pilots against the enemy's all affect how many enemy threats are destroyed. The Star Fleet Commander can determine how well each sector is doing by checking the performance data menu. This can be done by: (1) selecting Commander Options from the main menu, (2) select Show Data, and (3) select Performance Data, to obtain the performance data display. This displays performance data of the three most recent waves of attack of both sectors. An example is shown below.



Performance Data

Sector 1 Data

	Fr. Sent	En. Hit	En. Missed
last	5	2	6
last-1	4*	3	0
last-2	0	0	6

Sector 2 Data

	Fr. Sent	En. Hit	En. Missed
last	3	3	1
last-1	2*	0	6
last-2	0	0	5

Hit any key to Exit
Enemy Attacking 1 & 2

REINFORCEMENTS

The major responsibility of the Star Fleet Commander is to send reinforcements to the Star Fighter Commanders. These reinforcements can be sent at any time during the game but do not arrive until the following wave of attack. If fighters are not used within two attack waves from the time they were first received by the sector commander they will be sent back for refueling to the Star Fleet Commander. This effectively makes the fighter unavailable for the remainder of the game due to the time necessary to refuel and return to the fleet. Therefore, careful attention should be given to when and how many fighters are sent out to Sectors 1 and 2.

TAKING CONTROL OF A SECTOR

The Star Fleet Commander cannot directly vector star fighters to engage the enemy. However, you can order a Star Fighter Commander to send out fighters to engage incoming threats. The Star Fighter Commanders must respond to this order and promptly send out the number of fighters (1-9) that you instruct them to. The fighters will engage the enemy normally but the order must be given before the wave has ended. The Star Fleet Commander can order a Star Fighter Commander to vector fighters by choosing the Sector 1 Options (menu selection #1) or Sector 2 Options (menu selection #2) from the main menu. Then you must (1) Take Control, and (2) order the Star Fighter Commander to vector out "X number" of star fighters. You may then return to the main menu by pressing 1 which releases control of the sector. If you do not send the order to vector ships while in control, no fighters will be vectored toward the enemy, i.e., the Star Fighter Commander will wait for orders from you to send out fighters. If the Star Fleet Commander does not send the orders, no fighters will be sent out. When a new wave begins its approach, the control of the sector automatically reverts to the Star Fighter Commander.

INTELLIGENCE SOURCES

Throughout the game, intelligence data will be presented to both of the sector commanders and the Star Fleet Commander. The intelligence data that the Star Fighter Commanders receive to indicate the size of an incoming wave appears on the screen as Radar and Infrared intelligence information. This appears on the screen of Sector 1 and Sector 2 as well as on the screen of the Star Fleet Commander. This data indicates the number of incoming enemy threats attacking each sector during the current wave. This data is not entirely accurate but represents the best intelligence data available on the enemy attackers approaching the sectors. This data can give Sectors 1 and 2 sufficient information to make a decision regarding how many star fighters to send to destroy the enemy fighters. It can also be used by the Star Fleet Commander to decide how many fighters to send out if the Commander has taken control of a sector. The Radar and Infrared data should be weighted equally in the decision to vector star fighters toward the enemy.

The Star Fleet Commander also has available Long-Range Intelligence data called Federation and Alliance Intel which allows you to approximate how many enemies are approaching for the next wave of attack. This intelligence is not fully accurate since it is long range. However, this data can give you sufficient information to make a decision regarding how many star fighters to send to Sectors 1 and 2. As with the Short-Range Intel, this data should be weighted equally in the decision to vector fighters to Sectors 1 and 2 for reinforcements.

Now that you have had a chance to read over the fundamentals of the game we will now practice on the computer system. It is not expected that you will be an expert after reading this brief introduction, so do not be concerned. We will demonstrate the different menus and displays of the system, how to use them, and what they mean. We will go through this practice slowly and completely until you are comfortable with the entire game. Following the practice, you and your group members will play two real scenarios. You will be given a short questionnaire to fill out following each of these two missions. If you have any questions during the practice or the game itself, please do not hestitate to ask the experimenter. Good Luck and have fun!!!

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